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ABSTRACT

This curriculum guide was developed for courses in automobile body repair in secondary, postsecondary, and adult education classes in Oklahoma. It is designed for easy entry, easy exit in self-paced class situations as well as traditional courses. The curriculum contains 4 sections organized in 13 instructional units. The units follow a standard format established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. (Depending on the specific objectives of a unit, it may or may not contain transparency masters, supplements, assignment sheets, or job sheets.) All of the unit components focus on measurable and observable learning outcomes. The units in this curriculum cover the following topics: (1) welding; (2) metal repair--surface preparation, roughout, metal finishing, shrinking, and body filling; (3) fiberglass and plastic repair; and (4) hardware, glass, and trim. (KC)

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Automotive Body Repairer

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AUTOMOTIVE BODY REPAIRER

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FOREWORD

In Oklahoma, vocational educators have a basic belief that quality vocational programs require the use of sound instructional materials. A comprehensive approach with a quality treatment served as the primary approach when the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center began revisions of its instructional guide for the auto-body trade. This volume, *Automotive Body Repairer*, provides students in this area with an overview of the duties, procedures, concepts, tools, and equipment used in body repair. It supplements the first volume of this series, *Introduction to Auto Body*, and complements the other manuals that cover frame repair and refinishing. Throughout the series, every effort has been made to address the latest in technology with a special concern for the safety and health aspects associated with auto-body occupations.

Industry representatives, educators, and technical specialists collaborated closely to produce these materials in the hope that students will gain the knowledge and skills required in the auto-body trade through practical learning experiences. Coupled with the instructor's own methods and expertise, the materials should prove to be a valuable asset for a progressive auto-body training program.

It is our sincere wish that the manuals in this series will contribute to the development of a competent, safety-conscious work force in the auto-body trade.

Roy Peters, Jr., Director
Oklahoma State Department of
Vocational and Technical Education

Ivan Armstrong, State Supervisor
Trade and Industrial Education
Oklahoma State Department of
Vocational and Technical Education

PREFACE

The purpose of *Automotive Body Repairer* is to continue the student's training in the autobody trade by providing instruction in this specialty area. Instructional materials are also being developed for frame repair, refinishing, and shop management. Each volume has been carefully reviewed and validated by a committee of industry and education representatives concerned with presenting the latest advances of the trade.

These curriculum materials have been designed for use in full-time secondary and post-secondary classes, as well as part-time adult classes. The material is easily adaptable to open-entry, open-exit programs to allow students to progress at their individual paces.

A skilled instructor will be able to supplement, personalize, and localize this material to meet specific training needs. The design of the material allows the different topics to be presented in a variety of sequences, and even permits the use of part of a unit of instruction at a given time. The "Use of this Publication" section will greatly aid the instructor and student in getting the most from these materials. Additionally, the CIMC staff will be glad to assist you in tailoring these materials to your needs.

Bob Patton, Coordinator
Curriculum and Instructional
Materials Center
Oklahoma State Department of
Vocational and Technical Education

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ACKNOWLEDGEMENTS

Any project as comprehensive and involved as this guide for teaching auto-body repair requires the contributions of a great number of people. We are thankful for the tremendous support we have received in the development of this book.

Throughout the development of this book, we were guided by an able panel of experts from both the industry and education. This committee designed the scope and sequence of all the materials contained in this series and reviewed the completed materials for technical accuracy, teachability, currency, and industry relevance. We are especially grateful for the assistance given by representatives of the Independent Automotive Service Association and the Inter-Industry Conference on Automotive Collision Repair (ICAR). The review committee included

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We owe a great deal of gratitude to members of the Oklahoma State Department of Vocational and Technical Education staff who made the project possible, especially to Roy Peters, Jr., State Director; Ivan Armstrong, Trade and Industrial State Supervisor; and Bob Patton, CIMC Coordinator. These men recognized the need for these materials and dedicated the resources to see that the project was completed. We gratefully recognize the contributions of Dean Myers, who represented the Trade and Industrial Division, and Robert Hilley, who served as project coordinator for the CIMC.

We are also thankful to the many people involved in the production process. We received editorial guidance and assistance from the editing staff, supervised by Terri Barnes: we offer thanks to Sue Buck, Jerry Weir, and Marsha Sneed. We are also thankful to those in the Communications Center, under Debbie Hixson, who prepared the many drafts of this manual, with special thanks to Rose Primeaux, Stephanie Shipley, and Lisa Tomlinson.

The illustrations for this publication came from a number of sources. We are thankful to the many companies and publishers who contributed artwork, identified by the permission lines accompanying many of the illustrations. We are also grateful for the work done by the Art Department, under Bob Davis, and especially to Gary Bradley, Kim Hale, Kathryn Hansen, Robert Randall, and Scott Stone, who served as illustrators on this project. Recognition also is due to Tom Fields of the CIMC Media Unit who did the photographic work for this volume.

The quality of the published product is the result of the care and talents of the Print Shop personnel under the supervision of Noel Wilcoxson. None of this would have been possible without the dedication and skills of the CIMC secretarial staff under Judy DeVaughan, and especially the assistance of Janette Nicholson, secretary to the Development Unit. To these and many others, we are extremely grateful to have shared in this team effort.

It is our sincere hope that these materials will be of value to auto-body instructors and that they benefit those students who pursue careers in this vital and rewarding field.

Terry Walters

Susan S. Walker

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USE OF THIS PUBLICATION

Instructional Units

Automotive Body Repairer contains four sections and thirteen instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be transparency masters, supplements, assignment sheets, or job sheets included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

- Amount of material that can be covered in each class period
- Skills that must be demonstrated
  Supplies and equipment needed
  Amount of practice needed
  Amount of class time needed for demonstrations
- Supplementary materials, such as pamphlets and filmstrips, that must be ordered
- Resource people to contact

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective. Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives.

The objective sheet should be given to students and referred to throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine students' prior knowledge and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

Suggested activities are included only in teacher materials. The suggested activities pages include an outline of the unit contents and an instructor's guide designed to assist teachers in planning their presentation of the unit. The instructor's guide provides suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed in the suggested activities are ones used in the development of each unit. They may be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

The suggested activities section of the unit also includes supplements and transparency masters. Each of these components provides information in a special way. Supplements may consist of motivational materials, review or practice materials such as crossword puzzles and self-tests, or charts and reference materials. Supplements are designed to be copied and distributed to individual class members or to the class as a whole. Suggestions for their use are included in the instructor's guide. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification or analysis is necessary. Order transparencies from the Curriculum and Instructional Materials Center, or make transparencies and place them in the notebook where they will be immediately available for use.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical-outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience. They assist students in the application of knowledges that are necessary prerequisites to skill development. Assignment sheets may be given to the student for completion in class or may be used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress. The scores of those assignment sheets listed in the specific objectives should be averaged with the unit test score, as the skills addressed in these assignment sheets are considered necessary in meeting the unit objective.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Job sheet performance should be evaluated by the instructor and averaged with the unit test score, as the skills addressed in the job sheets are considered necessary in meeting the unit objective.

Tests (yellow pages)

The test provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 85 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score and evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

Answers to test and assignment sheets are components designed to assist the teacher in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center (CIMC) is assigned a specific abbreviation. For example, *Automotive Body Reparier* has been abbreviated ABR. The units are then numbered consecutively within each section. An example of a page number is ABR 1-A. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder for the units. This is convenient for taking the materials home to study. Upon completion, each unit is then placed in a larger binder. The large binders may be purchased at cost from the CIMC. Some teachers store the materials by units in filing cabinets or boxes until needed. All the units may be given out at once if desired.

For best results, provide student materials for each student. Student materials contain everything but the test answers, answers to assignment sheets, and suggested activities. All tests are collated at the back of student material and should be removed and stored until needed.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

Competency Profiles

Competency profiles are folders used to document student performance. The profile contains a list of the specific job competencies that a student should achieve prior to leaving the training program. Competency profiles may be ordered from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Manager of Development
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and
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INTRODUCTION TO WELDING AND CUTTING
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to discuss auto-body welding and cutting and set up various types of welding and cutting equipment. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent and the assignment sheet with a score of 100 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with auto-body welding and cutting.
2. Match to their common applications types of welding used in the auto-body shop.
3. Identify types of welds and joints.
4. Identify welding positions.
5. Discuss the effects of heat on metal.
6. State guidelines for welding aluminum and high-strength steels.
7. Select from a list characteristics of a good weld.
8. State welding safety rules.
9. Label components of oxyacetylene welding equipment.
10. Label components of metal-inert-gas (MIG) welding equipment.
11. Label components of resistance spot welding equipment.
12. Label components of plasma cutting equipment.
13. Demonstrate the ability to
    a. Set up oxyacetylene welding equipment.
    b. Set up metal-inert-gas (MIG) welding equipment.
    c. Set up plasma arc cutting equipment.
    d. Perform resistance spot welding.

INTRODUCTION TO WELDING AND CUTTING
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

  A. Objective sheet

  B. Suggested activities

  C. Information sheet

  D. Assignment Sheet #1 — Complete a Welding Safety Test

  E. Answers to assignment sheet

  F. Job sheets

    1. Job Sheet #1 — Set Up Oxyacetylene Welding Equipment

    2. Job Sheet #2 — Set Up Metal-Inert-Gas (MIG) Welding Equipment

    3. Job Sheet #3 — Set Up Plasma Arc Cutting Equipment

    4. Job Sheet #4 — Perform Resistance Spot Welding

  G. Test

  H. Answers to test

II. Instructor's guide

  A. Review unit and plan presentation.

  B. Order or obtain materials needed to present unit.

    1. Oxyacetylene, metal-inert-gas, resistance spot welding, and plasma cutting equipment and machines

    2. Equipment and materials necessary for job sheet completion

    3. Examples of good plasma cuts and different types of welds and joints

    4. Computer software: *Welding Equipment Safety and Operations*

       (NOTE: This computer software is compatible with Apple II; TRS-80 Models 1, 3 and 4; and TRS-80 Network 2 or 3. The software includes welding lessons and quizzes on oxyacetylene welding, oxyacetylene cutting and heating, arc welding, spot welding, and MIG welding. The disk, documentation, and quiz masters in a three-ring binder are available for approximately $70 from Teaching Aids Incorporated. Post Office Box 1798, Costa Mesa, California 92628-0798.)

SUGGESTED ACTIVITIES

5. Audiovisual programs

   (NOTE: The following welding programs are available from Bergwall Productions, Inc., as filmstrips, sound slides, or videocassettes. Order from Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238.)

   a. *Welding Explained: Oxyacetylene Fusion*; includes "Basic Nomenclature," "Preparing the Unit for Welding," "Lighting and Adjusting the Welding Flame," "Fusion Welding—Basic Application," "Fusion Welding—Varying Applications"

   b. *Oxyacetylene Cutting Explained*; includes "Setting Up Equipment," and "Specialized Oxyacetylene Cutting"

   c. *Welding Safety*; includes "Oxyacetylene Welding" and "Electric Arc Welding"

   d. *MIG Welding*; includes "Gas Metal Arc Welding Process," "Wire Feeders and Torches," "Short-Circuit Transfer," "Spray-Arc Transfer," and "Troubleshooting"

6. Safety and health literature

   a. ANSI Standard Z49.1, *Safety in Welding and Cutting*; available from the American Welding Society, 2501 N. W. 7th Street, Miami, Florida 33125

   b. OSHA Standard 29 CFR, Part 1910, Subpart Q, *Welding, Cutting, and Brazing*; available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

   c. NFPA Standard 51, *Oxygen-Fuel Gas Systems for Welding and Cutting* and NFPA Standard 51B, *Cutting and Welding Processes*; available from the National Fire Protection Association, 470 Atlantic Avenue, Boston, Massachusetts 02210

   d. CGA Pamphlet P-1, *Safe Handling of Compressed Gases in Cylinders*; available from the Compressed Gas Association, 500 Fifth Avenue, New York, New York 10036

7. Competency profiles

   (NOTE: Competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

SUGGESTED ACTIVITIES

D. Introduce unit.

SUGGESTIONS:

- Discuss welding and cutting applications in the auto-body shop.
- Stress safety consciousness.
- Discuss unit and specific objectives. Explain how learning the specific objectives leads to accomplishment of the unit objective.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms and definitions associated with welding and cutting.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss welding applications in the auto-body shop.

   SUGGESTION:

   - Show students completed welding jobs on various makes and models of vehicles.

3. Use Information Sheet, Section III to introduce students to different types of welds and joints.

   SUGGESTIONS:

   - Show students samples of the different types of welds and joints.
   - Make a bulletin board display of the different types of welds and joints.
   - Explain and show where the different types of welds and joints might be encountered in auto-body repair.

4. Use Information Sheet, Section IV to introduce students to the various welding positions.

   SUGGESTIONS:

   - Demonstrate each of the positions illustrated.
   - Allow students to practice the positions with the proper equipment but with the machines off.

SUGGESTED ACTIVITIES

5. Use Information Sheet, Section V to discuss the effects of heat on metal.

   SUGGESTIONS:

   - Take the students to the shop and demonstrate each of the effects on various types of metals.
   - Show students warped metals.
   - Allow students to practice heating various metals until they get a feel for how long it takes for each metal to soften and melt and what color the metal turns when heated to certain temperatures and for specific lengths of time.

6. Use Information Sheet, Section VI to explain guidelines for welding aluminum and high-strength steel.

7. Use Information Sheet, Section VII to show students the characteristics of a good weld.

   SUGGESTIONS:

   - Show students samples of good welds, pointing out those characteristics that make the welds good.
   - Make a bulletin board display of samples of good student welds.

8. Use Information Sheet, Section VIII to stress safety rules for welding and cutting.

   SUGGESTIONS:

   - Invite an experienced welder to speak to the class about welding accidents.
   - Stress the importance of selecting the correct lens shade and of wearing appropriate equipment and protective clothing.
   - Explain the fire hazard inherent in all welding and cutting processes.
   - Show audiovisuals on welding safety.
   - Provide students with copies of safety literature, or make a bulletin board display of this literature.
   - Use, or allow students to use, computer software program *Welding Equipment Safety and Operations*.
   - Review first-aid procedures for burns and eye injuries.
   - Have students complete Assignment Sheet #1.

SUGGESTED ACTIVITIES

9. Use Information Sheet, Sections IX, through XII to introduce students to components of oxyacetylene, metal-inert-gas (MIG), plasma cutting, and resistance spot welding equipment.

   SUGGESTIONS:

   - Show audiovisuals on oxyacetylene and MIG welding.
   - Show students the actual equipment. As you are explaining the equipment, demonstrate how to set it up.
   - Allow students to practice setting up the equipment, handling the cutting torch, welding in the various positions, and practicing rod manipulations with the welding and cutting machines off.
   - Demonstrate Job Sheets #1 through #4. Allow students to complete these job sheets under your supervision.

F. Give test.

   SUGGESTION:

   - Give the test a section at a time as the unit is taught.

G. Critique test and discuss in class.

H. Complete appropriate section of competency profiles.

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

B. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1974.

C. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*. Indianapolis, Indiana: The Bobbs-Merrill Company, Inc., 1983.

INTRODUCTION TO WELDING AND CUTTING
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Welding — Process of joining pieces of metal by heating them until they melt or fuse together

B. Oxyacetylene welding — Welding in which the source of heat is a flame from burning a mixture of oxygen and acetylene

C. Electrode — Device used to pass electrical current from power source across a nonconducting material

D. Metal-inert-gas (MIG) welding — Electrical welding in which the electrode is a wire fed from a roll to the weld and in which gas is used to protect or shield the weld from other gases in the air

E. Resistance spot welding — Electrical welding process using two electrode guns so that electricity may flow from either gun, through the material being welded, and to the other gun

(NOTE: Spot welding refers to creating a weld in only a very small area. Spot welding may be done with any type of welder, but resistance spot welders are designed exclusively for spot welding. Because two electrode guns are used, two spot welds are created at once. If the two welds are spaced out along one side of the joint, the process is called *noncompression resistance spot welding*. If spot welds are made on opposite sides of the joint—that is, the top and bottom of the metals—the process is referred to as *compression resistance spot welding*. Because of the frequent use of resistance spot welding to join body panels in the auto-body repair trade, the process is also known as *panel welding* or *panel spotting*.)

F. Braze welding — Oxyacetylene welding in which rods of brass are used

G. Oxyacetylene cutting — Use of an oxyacetylene flame to melt through (cut) metal

H. Plasma cutting — Use of a plasma arc to melt through (cut) metal

I. Heat distortion — Changes in size and shape of materials as the result of being exposed to high temperatures

(NOTE: Heat affects the chemical structure of most materials. Metals generally expand when heated. Under controlled conditions, these changes are useful to the auto-body technician. However, if the metal changes too much, it cannot be worked back into the desired shape. It has then become *distorted*.)

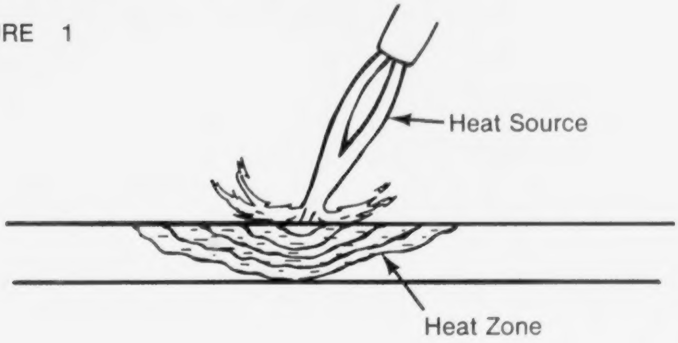
INFORMATION SHEET

J. Heat zone — Area within a material that is affected by the heat source

(NOTE: Heat spreads through materials such as metals. As more heat is applied the heat zone grows larger. See Figure 1.)

EXAMPLE:

FIGURE 1



K. Joint — Point or line where two pieces of metal contact each other to be welded

L. Bead — Build up of material along a weld

M. Flux — Chemical used in welding to control weld, improve fusion, and clean materials

(NOTE: Flux is available as a coating for electrodes or a core for rods.)

N. Purge — To cleanse or rid of impurities

II. Applications of types of welding used in the auto-body shop

A. Oxyacetylene welding — Welding mild steel or heavier metal parts where heat distortion is not a concern; heating or shrinking of metal

(NOTE: Oxyacetylene welding is normally used only for welding heavy metals in the auto-body shop, with almost no applications for sheet metal because of the large heat zone produced. Oxyacetylene welding is rare in today's auto-body shop and should *never* be used on unibody, HSLA steel.)

B. Oxyacetylene cutting — Cutting of seized bolts or hinges and of heavy metal parts such as frames or metal bumpers

(NOTE: Oxyacetylene cutting should be used in the auto-body shop only to remove heavy metal parts that are not going to be reused, such as cutting away a badly collapsed bumper to gain access to panel-to-frame fasteners. Remember, never apply heat to gas-filled energy-absorbing bumper systems without first discharging the gas.)

INFORMATION SHEET

C. Plasma cutting — High-speed cutting of any metal from gauge thickness to $^5/_{16}$-inch plate; piercing metal up to $^1/_8$-inch thick

(NOTE: Because it has a minimum heat-affected zone, plasma cutting is more suitable than oxyacetylene cutting for cutting new HSLA steels.)

D. Braze welding — Welding of soft metals such as brass or copper; joining two different kinds of metal

(NOTE: Braze welding is done with very low temperatures. Presently, braze welding is used mostly for joining two different types of metals where heat distortion must be avoided, such as the welding of brackets to other parts.)

E. Compression resistance spot welding — Installing clean replacement panels when both sides are accessible

(NOTE: Resistance spot welding requires clean surfaces free of paint and other materials and can only be done when electrodes are applied to both sides of the weld. For these reasons, uses in the auto-body shop may be extremely limited. Compression resistance spot welding is not recommended for unibody construction.)

F. Noncompression resistance spot welding — Installing clean, nonstructural panels when only one side is accessible

(NOTE: Because noncompression resistance spot welding fuses the joint on only one side, it produces a rather weak weld that cannot withstand high forces or lend structural support. Noncompression resistance spot welding is not recommended for unibody construction.)

G. MIG welding — Welding of thin-gauge metals and high-strength steels and alloys

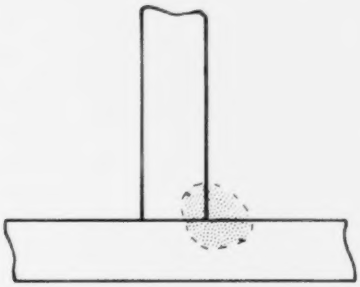
(NOTE: Because of its versatility and ease of use, as well as the fact that modern automotive construction extensively uses thin-gauge and high-strength metals, MIG welding is highly recommended for auto-body repair work.)

III. Types of welds and joints

A. Welds (Figures 2-6)

1. Fillet weld

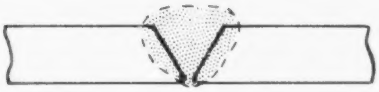
FIGURE 2



INFORMATION SHEET

2. Groove weld

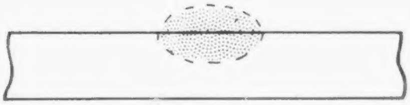
FIGURE 3



3. Bead weld

(NOTE: A bead weld is made with one pass of the electrode.)

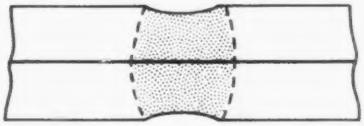
FIGURE 4



4. Spot weld

(NOTE: The metal in a resistance spot weld is fused. No filler or electrode rod is used.)

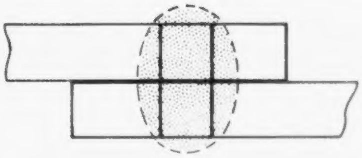
FIGURE 5



INFORMATION SHEET

5. Plug weld

FIGURE 6

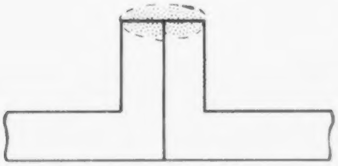


B. Weld joints (Figures 7-11)

1. Edge joint

(NOTE: In an edge joint, two pieces of metal are placed against each other with one set of ends flush. The weld is made along the common edge.)

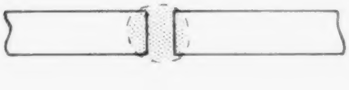
FIGURE 7



2. Butt joint

(NOTE: Butt joints are often beveled for better penetration.)

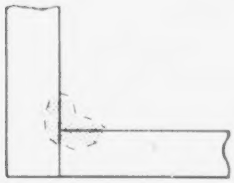
FIGURE 8



INFORMATION SHEET

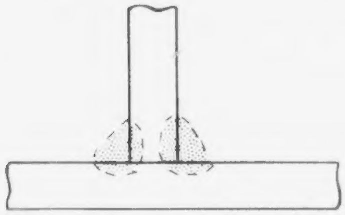
3. Corner joint

FIGURE 9



4. Tee (T) joint

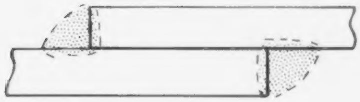
FIGURE 10



5. Lap joint

(NOTE: In a lap joint, the two pieces of metal overlap each other and a fillet weld is made at one or both ends of the lap.)

FIGURE 11

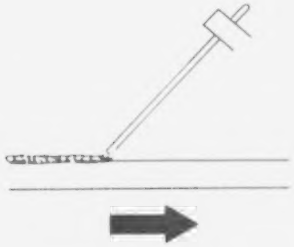


INFORMATION SHEET

IV. Positions used in welding (Figures 12-16)

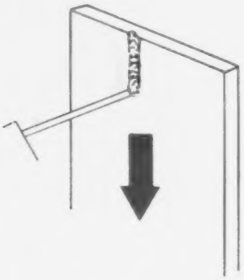
A. Flat

FIGURE 12



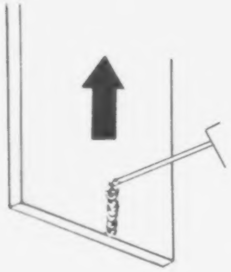
B. Vertical down

FIGURE 13



C. Vertical up

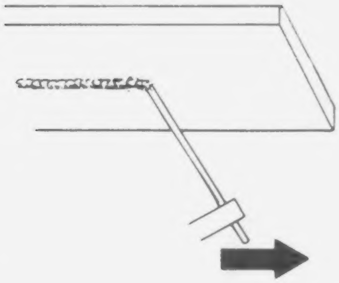
FIGURE 14



INFORMATION SHEET

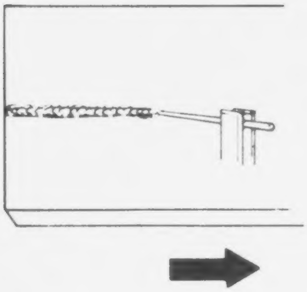
D. Overhead

FIGURE 15



E. Horizontal

FIGURE 16



V. Effects of heat on metal

A. Metal expands when heated

(NOTE: Expansion is normally toward the source of heat. For example, if a torch is held near a piece of sheet metal, a "bump" will rise up on the surface.)

B. The more heat added, the greater the expansion, and the larger the area affected

(NOTE: If the heat spreads to an unattached edge of the metal, the metal will warp as shown in Figure 17.)

INFORMATION SHEET

EXAMPLE:

FIGURE 17

C. Heat softens metal

(NOTE: This effect of heat is helpful for the auto-body technician because softened metal can be shaped using proper tools and procedures. For example, metal is hardened when it is bent or hammered, and heat can be used to soften such work-hardened metal. These procedures are covered in detail in Section B, Unit IV.)

D. With the continued application of heat, metal will eventually melt

(NOTE: The temperature at which metal begins to flow like a liquid is called its *melting point*. Table 1 shows the melting points of various metals that may be found in a body shop.)

TABLE 1: Melting Points of Common Metals

Metal	Melting Point (°F)
Aluminum	1220 to 1250
Brass	1615 to 1950
Copper	1840 to 1900
Mild steel	2500 to 2700
High-strength low-alloy steel	2700 to 2900

E. As heated metal cools, it shrinks

(NOTE: The faster heated metal cools, the more it shrinks. An auto-body technician can control the amount of shrinkage by controlling the rate at which the metal cools.)

VI. Guidelines for welding aluminum and high-strength steels

A. Aluminum

1. Use low heat-producing procedures

EXAMPLES: Acetylene—rich flames, low amperages, short heat application periods

INFORMATION SHEET

(NOTE: As shown in Table 1, aluminum has a relatively low melting point. Additionally, aluminum is an extremely good conductor of heat. For these reasons, the heat must be controlled carefully to prevent melting and to limit heat distortion.)

2. Thoroughly clean surfaces to be welded, and use flux to reduce oxide formation

   (NOTE: Aluminum oxidizes easily when heated—that is, the metal combines with oxygen to produce powdery scum. This oxidation prevents the weld from joining the parts securely. Flux cleans away oxidation.)

3. Work quickly and keep the welding tip moving in small circles to spread the heat

   (NOTE: Besides having a low melting point, aluminum gives little indication that it is about to melt, such as the color change observed in steel.)

4. Direct welding tip so that heat is applied to both weld and adjoining metal

   (NOTE: Generally, this requires that the welding tip be held at a closer than normal angle to the surface being welded.)

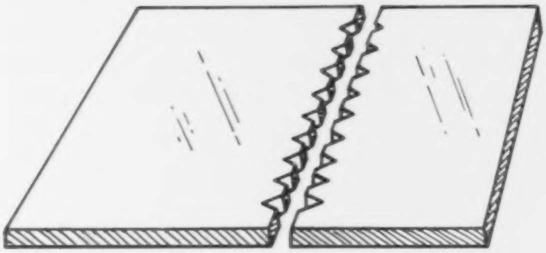
5. Preheat area to be welded

6. Notch joint edges when butt-welding aluminum thicker than ½ inch (Figure 18)

   (NOTE: Notching increases the area of surface contact and strengthens the weld.)

   EXAMPLE:

FIGURE 18



INFORMATION SHEET

7. Because aluminum cools so quickly, avoid buckling the metal when cooling it with water

   (NOTE: Other techniques are used by various technicians when welding aluminum. Some use blue lenses in their goggles when doing oxyacetylene welding. Blue lenses provide better vision when using the lower temperature acetylene-rich flame. Also, some technicians preheat aluminum by heating it with an acetylene-rich flame to create soot on the surface, and then apply a normal flame until the soot burns away. Each technician must practice welding procedures and adopt those techniques found to be most successful.)

B. High-strength steels

(NOTE: High-strength steels [HSS] and high-strength low-alloy steels [HSLA] can be significantly weakened if heated above a specific temperature, called *critical temperature*. Also, the specific use of the metal in the vehicle determines whether or not it should be heated. Always follow the manufacturer's recommendations with regard to temperatures and procedures. When in doubt, do not use heat in any form on these types of steels.)

1. Use low heat-producing procedures and do not apply heat over the critical temperature

2. Heat only small areas

3. Keep the welding tip moving

4. Apply heat for short periods only

   (NOTE: Some industry experts recommend that no area be heated for more than three minutes at a time. Some technicians like to use temperature-indicating crayons or temp-sticks to monitor heat build up.)

5. Allow heated areas to cool at their own rates

   (NOTE: Do not use water or compressed air to cool HSS or HSLA steel.)

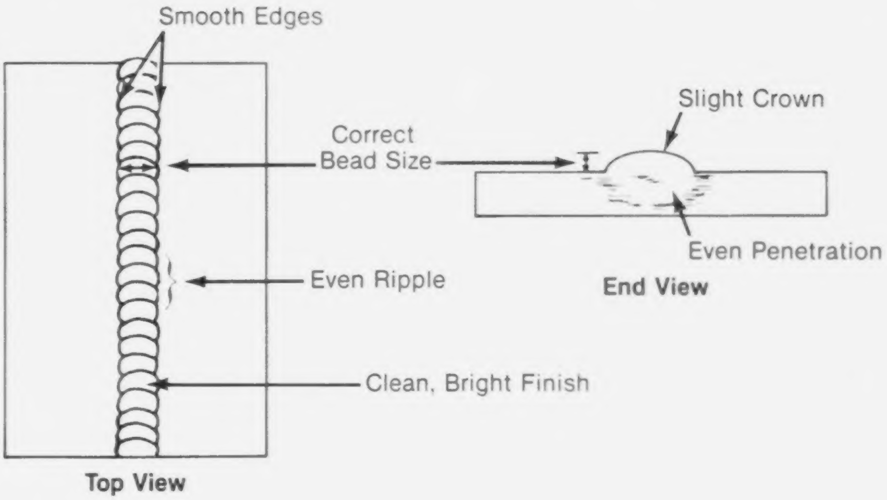
6. Use MIG welding procedures if welding must be done

VII. Characteristics of a good weld (Figure 19)

(NOTE: Specific welding applications, materials, and procedures determine the exact characteristics for any particular weld. The characteristics illustrated on the next page are general qualities and should be given weight only as required for each specific job.)

INFORMATION SHEET

FIGURE 19



VIII. Welding safety rules

(NOTE: The following safety rules apply any time welding-type equipment is in use, whether you are using it for welding, cutting, brazing, or heating. Your instructor may add additional rules.)

A. General

1. Wear proper protective clothing and eye protection

   (NOTE: Eye protection and protective clothing are required for anyone working in the immediate area of welding. Be sure that other people in the shop, especially visitors, are cautioned not to look at welding arcs or flames.)

2. Use equipment and accessories that are in good condition
3. Make sure that a fire extinguisher is available suitable for fires involving materials in the work area
4. Weld only with adequate ventilation

   (NOTE: If you feel dizzy or nauseated or if you have blurred vision, shut down the equipment and get some fresh air.)

5. Avoid breathing welding fumes

   (NOTE: Some types of metals and metallic coatings, as well as paints, give off toxic fumes. Be especially careful when welding on or near such materials.)

INFORMATION SHEET

6. Wear welding gloves to handle hot metals

7. Assume as comfortable and unconfined a position as possible, with ready access to welding controls

8. Do not weld on concrete, gravel, or cement

   (NOTE: Concrete and cement explode when exposed to high heat.)

9. Do not weld on or near combustible materials

   (NOTE: Be especially careful when welding near fuel lines and systems. Never weld on a gas tank.)

10. Do not leave welding equipment turned on and unattended

11. Keep work area, equipment, and clothing clean at all times

    (NOTE: Be especially careful with grease, lubricants, solvents, paints, and fuels. These materials can make your clothing highly-flammable.)

B. Gas welding and cutting

1. Set up cylinders at least 5 feet from welding location

   (NOTE: Remember that gas cylinders are used for both oxyacetylene and MIG welding.)

2. Handle cylinders with care, being especially careful to avoid damaging valves and regulators

3. Store cylinders in an upright position and secure with a chain

4. Always use regulators; do not use gases directly from cylinders

   (NOTE: Be sure that a properly operating regulator is correctly installed on each cylinder in use.)

5. Never use oil or grease on regulators, fittings, torches, or any surface that may come into contact with compressed oxygen

   (NOTE: Compressed oxygen is explosive. Use it only for its intended purpose. Compressed oxygen should *never* be used for cleaning clothing or parts, for drying wet surfaces, for operating tools, or for any purpose other than welding.)

6. Do not breathe gases—including oxygen—directly from cylinders

7. Use only hoses in good condition and those designated for the gas being used

INFORMATION SHEET

8. Use soapsuds and a clean paintbrush to test connections and hoses for leaks

   (NOTE: Use Ivory or a similar soap that does not contain oils.)

9. Do not use acetylene at pressures higher than 15 pounds per square inch (psi)

   (NOTE: Specific welding jobs require different gas pressures. Follow the recommendations of manufacturers or of appropriate organizations such as the American Welding Society.)

10. Light torches *only* with proper lighters

    (NOTE: Do not use matches, cigarette lighters, lighted cigarettes, or other flames.)

C. Electric welding

(NOTE: Electric welding includes resistance spot welding, MIG welding, and other methods not covered in these materials.)

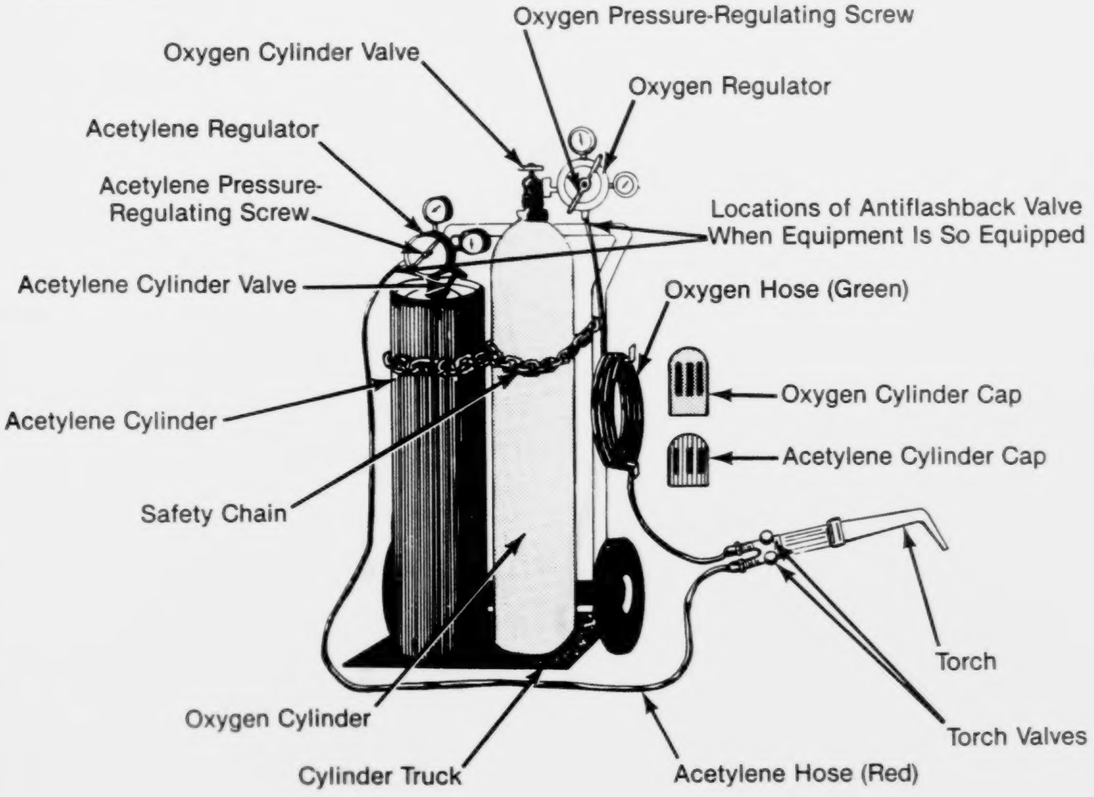
1. Use eye protection when chipping slag
2. Disconnect power before servicing machine
3. When power is on, do not allow electrode holder or gun to come into contact with grounded metal
4. Weld only in a dry area; do not weld while standing on a wet surface
5. Dispose of electrode stubs properly

INFORMATION SHEET

IX. Components of oxyacetylene welding equipment (Figure 20)

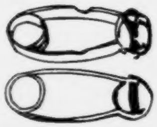
(NOTE: As an added safety feature, some oxyacetylene rigs are equipped with antiflashback valves between the regulators and torch.)

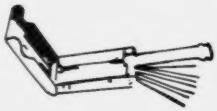
FIGURE 20



Welding Goggles

Welding Gloves


Flint Lighters

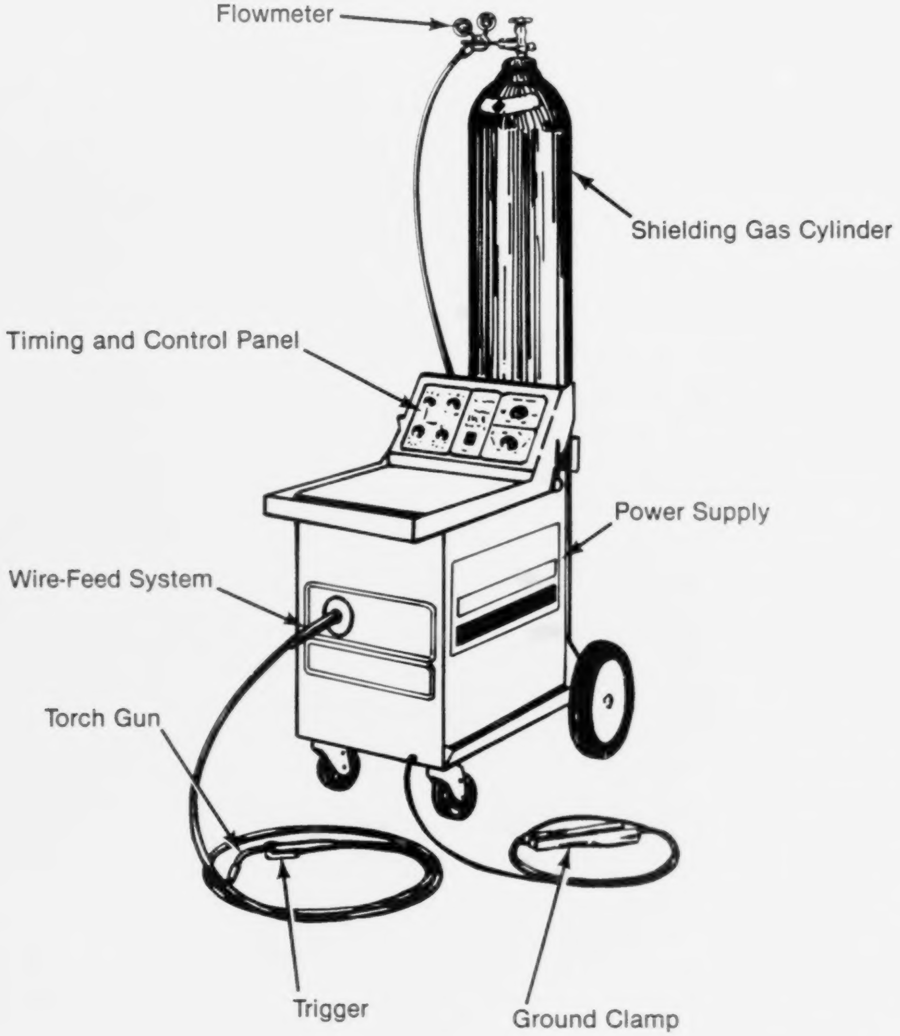

Tip Cleaners

INFORMATION SHEET

X. Components of metal-inert-gas (MIG) welding equipment (Figure 21)

(NOTE: Basically the same accessories are required for MIG welding as are required for oxyacetylene welding.)

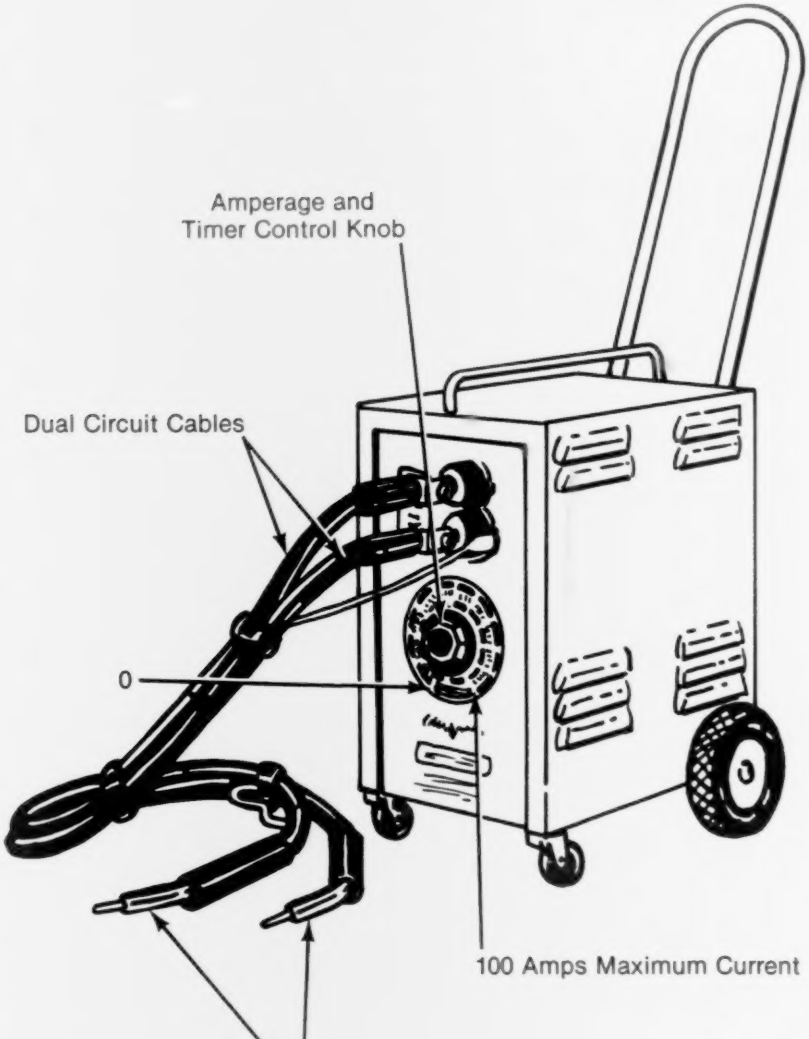
FIGURE 21



INFORMATION SHEET

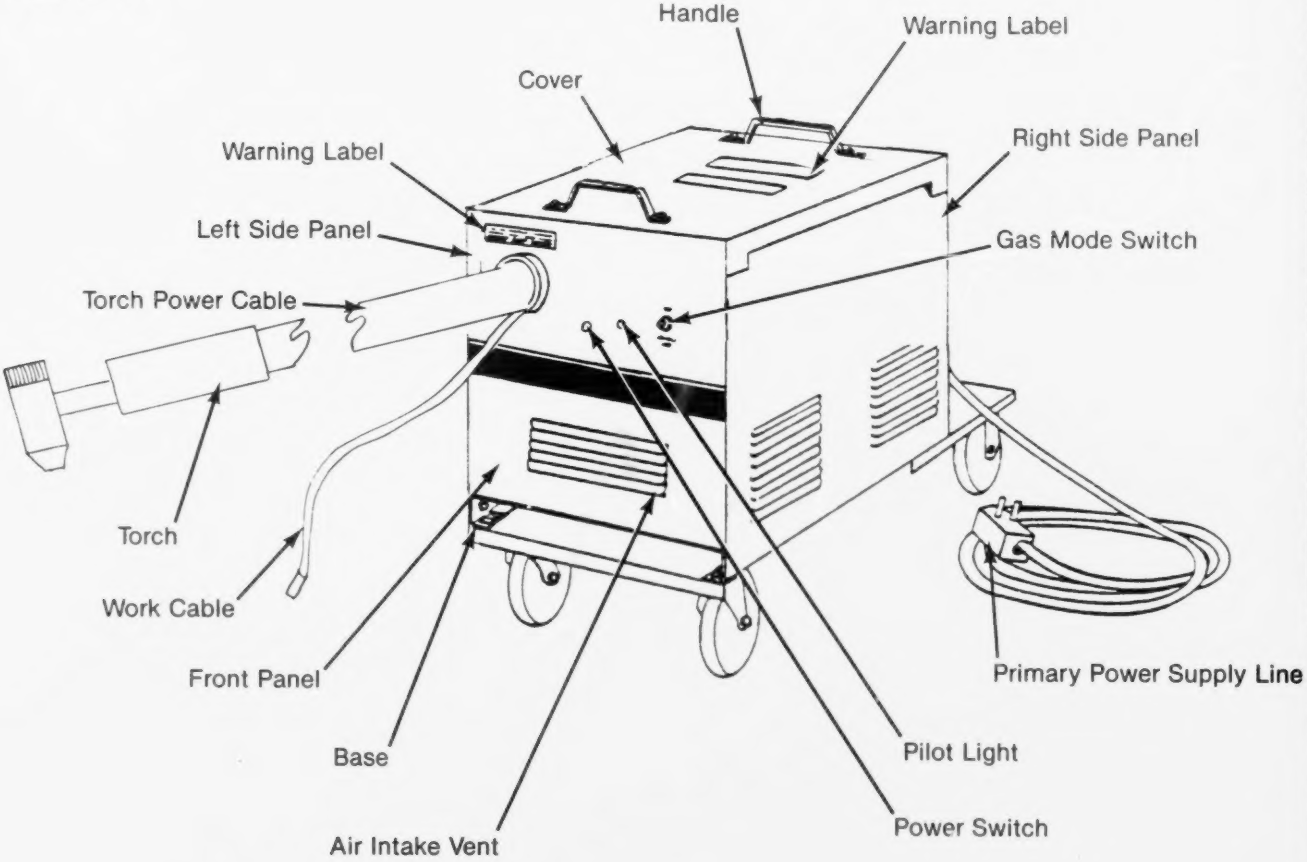
XI. Components of resistance spot welding equipment (Figure 22)

FIGURE 22



XII. Components of a plasma arc cutting system (Figure 23)

FIGURE 23



INTRODUCTION TO WELDING AND CUTTING
UNIT I

ASSIGNMENT SHEET #1 — COMPLETE A WELDING SAFETY TEST

NAME ______________________________ SCORE ______________

There are many dangers in the auto-body shop, but one of the most potentially serious is welding equipment. Welding and other heating processes involve the use of open flames or electrical arcs around combustible and even explosive materials. Additionally, there are dangers from the heat itself, the handling of hot parts, and the breathing of gases given off by heated materials. Furthermore, blindness and impaired vision frequently result from carelessness around welding operations, even among experienced professionals who should know to wear eye protection and to use properly shaded lenses for the type of welding being done.

You have studied some safety rules, and in this assignment sheet you will be tested over those rules. But simply knowing the rules is not enough; you must follow the rules and insist that others in the shop obey them also. You must be alert to potential hazards, and you must prevent such hazards before any damage is done.

Give a welding safety rule for each of the following words or phrases. You must score 100 percent on this assignment sheet before you will be allowed to handle or operate any welding equipment.

PART I — General safety rules

A. Protective clothing and eye protection — ______________________________

____

B. Equipment and accessories — ______________________________

____

C. Fire extinguisher — ______________________________

____

D. Ventilation — ______________________________

____

E. Fumes — ______________________________

____

F. Hot metals — ______________________________

____

ASSIGNMENT SHEET #1

G. Welding position — ______________________________

____

H. Concrete, gravel, and cement — ______________________________

____

I. Combustible materials — ______________________________

____

J. Leaving welding equipment — ______________________________

____

K. Cleanliness — ______________________________

____

PART II — Gas welding and cutting

A. Securing cylinders — ______________________________

____

B. Handling cylinders — ______________________________

____

C. Regulators — ______________________________

____

D. Oil and grease — ______________________________

____

E. Breathing gases — ______________________________

____

F. Hoses — ______________________________

____

G. Checking for leaks — ______________________________

____

ASSIGNMENT SHEET #1

H. Acetylene pressure — ______________________________

____

I. Lighting torches — ______________________________

____

PART III — Electric welding

A. Chipping slag — ______________________________

____

B. Servicing machine — ______________________________

____

C. Grounded metal — ______________________________

____

D. Wet areas — ______________________________

____

E. Electrode stubs — ______________________________

____

INTRODUCTION TO WELDING AND CUTTING
UNIT I

ANSWERS TO ASSIGNMENT SHEET

Assignment Sheet #1

PART I — General safety rules

A. Wear proper protective clothing and eye protection
B. Use equipment and accessories that are in good condition
C. Make sure that a fire extinguisher is available suitable for fires involving materials in the work area
D. Weld only with adequate ventilation
E. Avoid breathing welding fumes
F. Wear welding gloves to handle hot metals
G. Assume as comfortable and unconfined a position as possible, with ready access to welding controls
H. Do not weld on concrete, gravel, or cement
I. Do not weld near combustible materials
J. Do not leave welding equipment turned on and unattended

PARTII — Gas welding and cutting

A. Set up cylinders at least 5 feet from welding location
B. Handle cylinders with care, being especially careful to avoid damaging valves and regulators
C. Store cylinders in an upright position and secure with a chain
D. Always use regulators; do not use gases directly from cylinders
E. Never use oil or grease on regulators, fittings, torches, or any surface
F. Do not breathe gases—including oxygen—directly from the cylinders
G. Use only hoses in good condition and those designated for the gas being used
H. Use soapsuds and a clean paintbrush to test connections and hoses for leaks
I. Do not use acetylene at pressures higher than 15 pounds per square inch (psi)
J. Light torches *only* with proper lighters

PART III — Electric welding

A. Use eye protection when chipping slag
B. Disconnect power before servicing machine
C. When power is on, do not allow electrode holder or gun to come into contact with grounded metal
D. Weld only in a dry area; do not weld while standing on a wet surface
E. Dispose of electrode stubs properly

INTRODUCTION TO WELDING AND CUTTING
UNIT I

JOB SHEET #1 — SET UP OXYACETYLENE WELDING EQUIPMENT

I. Equipment and materials

   A. Oxygen cylinder

   B. Acetylene cylinder

   C. Oxygen regulator

   D. Acetylene regulator

   E. Hoses

   F. Wrench

   G. Cylinder holder

   H. Ivory or similar soap that does not contain oils

   I. Clean paintbrush

   J. Protective clothing and eye protection

   K. Torch body with appropriate tips

II. Procedure

(NOTE: This procedure is designed to acquaint you with oxyacetylene equipment. You will set up the equipment and then practice manipulating the various components without a flame.)

   A. Put on protective clothing and eye protection

   B. Inspect work area to make sure that it is free of flammable materials and is well-ventilated; note location of nearest fire extinguisher

   C. Fasten cylinders in a vertical position

   D. Remove caps from cylinders

   E. Crack valves of each cylinder and then close

   F. Connect oxygen regulator to oxygen cylinder

      1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

2. Slowly turn cylinder valve wide open

3. Close cylinder valve

G. Connect acetylene regulator to acetylene cylinder

1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

2. Slowly open cylinder valve one-quarter to one-half turn

3. Close cylinder valve

H. Connect acetylene hose to acetylene regulator; purge hose

I. Connect oxygen hose to oxygen regulator; purge hose

J. Connect torch body to oxygen and acetylene hose and close both valves on torch body

K. Attach tip to torch body; purge torch

(NOTE: The tip size is determined by the thickness of the metal to be welded and the manufacturer's recommendations.)

L. Adjust oxygen regulator to recommended working pressure

1. Turn adjusting screw on regulator clockwise until working pressure is indicated on gauge

2. Open torch valve

(NOTE: When the torch valve is opened, the working pressure reading will change.)

3. Readjust regulator clockwise until recommended working pressure is again indicated on gauge

M. Adjust acetylene regulator to recommended working pressure

1. Turn adjusting screw on regulator clockwise until working pressure is indicated on gauge

2. Open torch valve

(NOTE: When the torch valve is opened, the working pressure reading will change.)

3. Readjust regulator clockwise until recommended working pressure is again indicated on gauge

JOB SHEET #1

- N. Apply soapsuds with a clean paintbrush to test all connections for leaks
- O. Tighten loose connections if required

III. Procedure for turning off the flame and oxyacetylene unit

- A. Close acetylene valve on torch
- B. Close oxygen valve on torch
- C. Close acetylene cylinder valve
- D. Close oxygen cylinder valve
- E. Open acetylene valve on torch
- F. When gauges reach zero, close torch valve and release adjusting screw on acetylene regulator by turning counterclockwise
- G. Open oxygen valve on torch
- H. When gauges reach zero, close oxygen valve and release adjusting screw on oxygen regulator by turning counterclockwise
- I. Practice manipulating oxyacetylene equipment along weld joints
- J. Place torch and hose on hanger or brackets provided
- K. Clean work area and return equipment and materials to proper storage

INTRODUCTION TO WELDING AND CUTTING
UNIT I

JOB SHEET #2 — SET UP METAL-INERT-GAS (MIG) WELDING EQUIPMENT

I. Equipment and materials

   A. MIG power supply, feeder wire, and gun

   B. Shielding gas

   C. Electrode filler wire

   D. Protective clothing and eye protection

   E. Appropriate fire extinguisher

   F. Ivory or similar soap that does not contain oils

   G. Clean paintbrush

II. Set up procedure

   A. Put on protective clothing and eye protection

   B. Inspect work area to make sure that it is free of flammable materials and is well-ventilated; note location of nearest fire extinguisher

   C. Position welder near work area

   D. Set power supply controls as follows

      1. Push start switch or start engine if engine driven

      2. Set machine controls

         a. Set voltage for arc desired

         b. Set inductance for arc desired

         c. Set slope to reading indicated by instructor

   E. Set up wire feed

      1. Set for size and type of wire being used

      2. Set for size of feed roll being used

      3. Inch wire out to gun using incher control

4. Adjust tension on feed rolls

   (NOTE: Tension should be tight enough to feed wire but should not deform or mark wire.)

5. Turn on power switch

F. Set up and adjust shielding gas controls

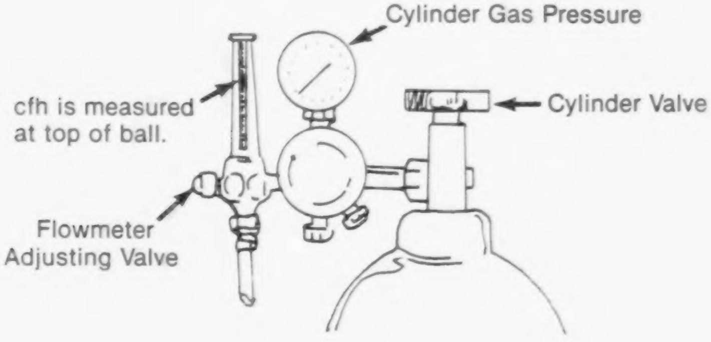
1. Purge cylinder valve to remove any dirt or foreign material
2. Mount gas flowmeter to cylinder in a vertical position
3. Crack cylinder valve slowly
4. Check for leaks, using soapsuds and clean paintbrush
5. Turn wire-speed control to zero or release pressure on feed rolls
6. Open flowmeter adjusting valve slowly while depressing gun trigger

   (NOTE: Some machines have preset regulators and are not adjusted manually.)

7. Adjust to desired flow rate (cubic feet per hour [cfh] indicated by your instructor) and release trigger (Figure 24)

   (NOTE: The flowmeter is accurate only if gas in cylinder exceeds 50 psi with the cylinder mounted vertically.)

FIGURE 24



G. Set wire-feed speed (amperage control) to setting indicated by your instructor

(NOTE: Arc voltage and amps should be fine tuned while or after running a bead on scrap metal.)

JOB SHEET #2

H. Set up gun

1. Inspect wire conduit

   (NOTE: Conduit and liners that transport the wire to the gun should be the correct size, as well as clean and free of obstructions.)

2. Inspect contact tip or tube

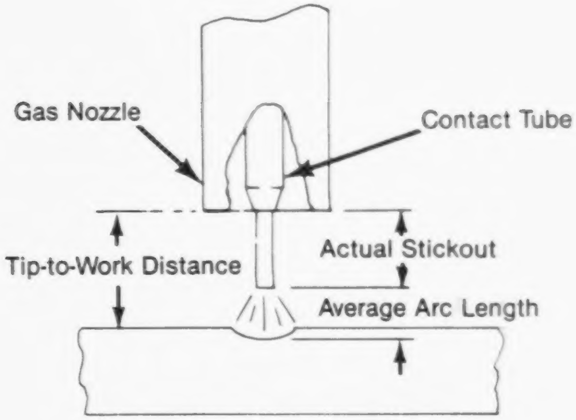
   (NOTE: Contact tip or tube should be the correct size for wire being used and should be free of grease, dirt, or spatter)

3. Inspect nozzle

   (NOTE: The nozzle should be the correct size for welding applications and gas flow volumes and should be free of spatter. Some form of anti-spatter compound, either spray or paste, should be applied to the nozzle and contact tip before welding to help prevent spatter build up.)

4. Adjust and maintain stickout recommended by instructor (Figure 25)

FIGURE 25



III. Shutdown procedure

A. Turn off wire-feed speed control

1. Set control to zero
2. Bleed gas lines
3. Move wire-feed control switch to OFF

JOB SHEET #2

B. Shut off shielding gas system if used

   1. Close cylinder valve

   2. Depress welding gun trigger until ball in flowmeter zeros

   3. Close flowmeter adjusting valve until it is finger tight

C. Turn off welding power supply

D. Practice manipulating gun along weld joints

E. Store gun and cable assembly in correct place

F. Clean work area and return equipment and materials to proper storage

INTRODUCTION TO WELDING AND CUTTING
UNIT I

JOB SHEET #3 — SET UP PLASMA ARC CUTTING EQUIPMENT

I. Equipment and materials

A. Plasma arc cutting outfit

B. Cutting tips

C. Compressed or shop air

D. Wrench

E. Appropriate screwdriver

F. Manufacturer's instruction manual

G. Protective clothing and eye protection

II. Procedure

(NOTE: This procedure is designed to acquaint you with plasma cutting equipment. You will set up the equipment and then practice manipulating the various components without power to the equipment.)

A. Put on protective clothing and eye protection

B. Inspect work area to make sure that it is free of flammable materials and is well-ventilated; note location of nearest fire extinguisher

C. Install torch and make work cable connections

1. Remove top cover and left side panel from power supply outfit

2. Thread terminal lug end of work cable assembly through bushing on front panel and connect it to WORK terminal board; wrench tighten

3. Thread power cable and switch lead through the same bushing

4. Connect power cable to NEG output fitting on terminal board; wrench tighten

5. Plug switch lead into receptacle on output terminal board; make sure that lead is firmly locked in place

6. If using shop air, connect filter-regulator nipple outlet to gas connection on rear panel of power supply unit, and then connect air supply to inlet connection of filter-regulator

7. If using cylinder air, read, understand, and follow all instructions packed with the regulator before connecting regulator to cylinder

8. Assemble adaptor to gas connection on rear panel, and then connect hose to adaptor and regulator outlet, tightening connections firmly with wrench

JOB SHEET #3

9. Reinstall side panels and top cover of power supply unit; tighten all screws firmly
10. Clamp work cable to workpiece as shown in Figure 26, and be sure that workpiece is connected to an approved earth ground with the proper-size ground cable
11. Install cutting tip on torch body following directions in manufacturer's instruction manual

D. Adjust controls

1. Slowly open air (gas) cylinder valve
2. Place power supply unit gas mode switch in the SET-UP position
3. Place power switch in the OFF position
4. Plug unit into wall receptacle
5. Place power switch in READY position

   (NOTE: The pilot light should light up, indicating that the control circuits are energized.)

6. Adjust regulator to deliver 50 psi, and allow gas to flow for a few minutes to remove any condensation that may have accumulated during shutdown
7. Place gas mode switch in the OPERATE position to shut off gas flow

   (NOTE: The unit is now set up for cutting. To cut, all the technician need do at this point is depress the torch switch.)

E. Shut down torch by placing gas mode switch in OFF position

F. Disconnect unit from wall receptacle

G. Practice holding cutting torch and manipulating equipment as for cutting

H. Clean work area and return equipment and materials to proper storage

INTRODUCTION TO WELDING AND CUTTING
UNIT I

JOB SHEET #4 — PERFORM RESISTANCE SPOT WELDING

I. Equipment and materials

A. Resistance spot welder

B. Protective clothing and eye protection

C. Wire brush

D. Several sheets of various types of metal

(NOTE: Your instructor may have you practice on wrecked vehicles. Resistance spot welding should never be used on vehicles with unibody construction.)

E. Appropriate fire extinguisher

F. C-clamps or vise

II. Procedure

A. Put on protective clothing and eye protection

B. Inspect work area to make sure that it is free of flammable materials and is well-ventilated; note location of nearest fire extinguisher

C. Position welder near work area

D. Determine type of spot weld to be made and approximate location of weld

(NOTE: The main determination to be made is whether compression or non-compression spot welding will be performed. This determination will be based on the type of metal being welded, its function in the vehicle's construction, the type of repair being performed, accessibility to joint, type of joint, technician preferences, and other factors.)

E. Inspect work surfaces and clean if necessary

(NOTE: Surfaces must be clean and free of deposits, dirt, oil, grease, and paint. Use wire brushes, sandblasting, solvents, or other cleaning methods as required. Remember that each weld point and the points of contact between the two surfaces must be clean.)

F. Set amperage and time, following welder manufacturer's recommendations

JOB SHEET #4

G. Position panels; clamp in place or have a helper hold them

CAUTION

The helper must wear the same kind of protective clothing and eye protection as the operator.

H. Hold electrode guns in place as close to a right angle as possible

I. Pull trigger or push control button on one electrode gun

(NOTE: Current will automatically flow at the set amperage and shut off after the set cycle time.)

J. Inspect welds

K. Adjust amperage and time as required if weld must be changed

L. Continue welding along joint until job is complete

M. Practice welding several types of joints and metals, following your instructor's directions

N. Clean welds with wire brush

O. Turn off welding machine and store electrode guns

(NOTE: The welding tips must be cleaned or replaced periodically. Follow the manufacturer's recommendations for tip maintenance.)

P. Clean work area and return equipment and materials to proper storage

INTRODUCTION TO WELDING AND CUTTING
UNIT I

TEST

NAME ________________________ ______________ SCORE ______________

1. Match to their correct definitions terms associated with auto-body welding and cutting. Write the correct numbers in the blanks.

_____a. Device used to pass electrical current from power source across a nonconducting material

_____b. Electrical welding in which the electrode is a wire fed from a roll to the weld and in which gas is used to protect or shield the weld from other gases in the air

_____c. Process of joining pieces of metal by heating them until they melt or fuse together

_____d. Use of a plasma arc to melt through (cut) metal

_____e. Use of an oxyacetylene flame to melt through (cut) metal

_____f. Area within a material that is affected by the heat source

_____g. Oxyacetylene welding in which rods of brass are used

_____h. Welding in which the source of heat is a flame from burning a mixture of oxygen and acetylene

_____i. Changes in size and shape of materials as the result of being exposed to high temperatures

_____j. Electrical welding process using two electrode guns so that electricity may flow from either gun, through the material being welded, and to the other gun

_____k. Chemical used in welding to control weld, improve fusion, and clean materials

_____l. Point or line where two pieces of metal contact each other to be welded

_____m. Buildup of material along a weld

_____n. To cleanse or rid of impurities

1. Heat distortion
2. Heat zone
3. Welding
4. Joint
5. Oxyacetylene welding
6. Plasma cutting
7. Electrode
8. Flux
9. Bead
10. Metal-inert-gas (MIG) welding
11. Resistance spot welding
12. Braze welding
13. Oxyacetylene cutting
14. Purge

TEST

2. Match to their common applications types of welding used in the auto-body shop. Write the correct numbers in the blanks.

_____a. High-speed cutting of any metal from gauge thickness to $^{5}/_{16}$-inch plate; piercing metal up to $^{1}/_{8}$-inch thick

_____b. Welding mild steel or heavier metal parts where heat distortion is not a concern; heating or shrinking of metal

_____c. Cutting of seized bolts or hinges and of heavy metal parts such as frames or metal bumpers

_____d. Installing clean, nonstructural panels when only one side is accessible

_____e. Welding of soft metals such as brass or copper; joining two different kinds of metal

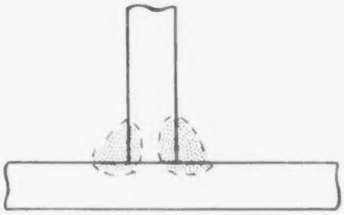
_____f. Welding of thin-gauge metals and high-strength steels and alloys

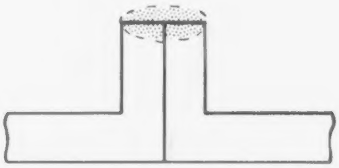
_____g. Installing clean replacement panels when both sides are accessible

1. Oxyacetylene welding
2. Oxyacetylene cutting
3. Plasma cutting
4. Braze welding
5. Compression resistance spot welding
6. Noncompression resistance spot welding
7. MIG welding

3. Identify the following types of welds and joints. Write the correct names in the blanks.

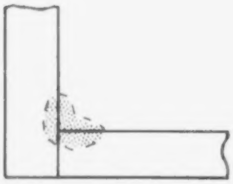
Fillet weld
Groove weld
Bead weld
Spot weld
Edge joint
Butt joint
Corner joint
Tee (T) joint
Lap joint
Plug weld



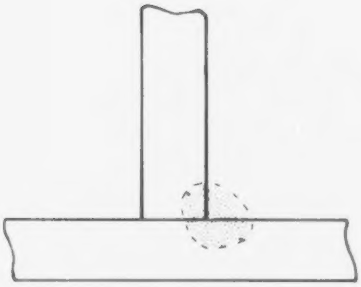


a. ______________________ b. ______________________

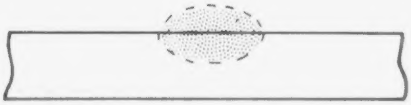
TEST



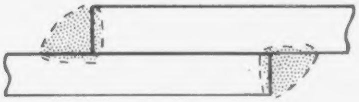
c. ______________________



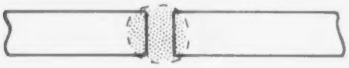
d. ______________________



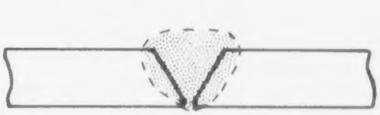
e. ______________________



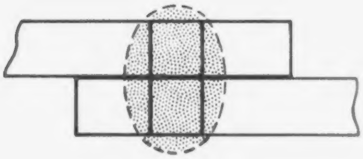
f. ______________________



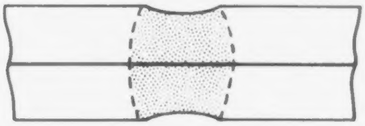
g. ______________________



h. ______________________



i. ______________________

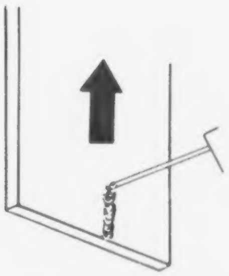


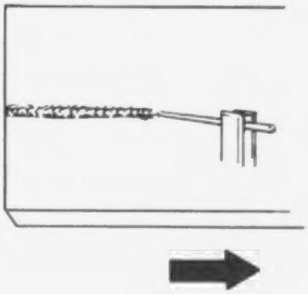
j. ______________________

TEST

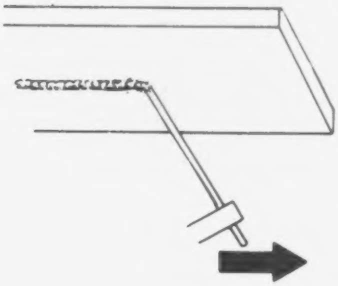
4. Identify the welding positions in the following illustrations. Write the correct names in the blanks.

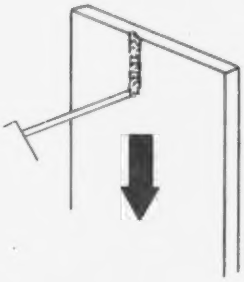
Flat **Vertical down** **Vertical up** **Overhead** **Horizontal**



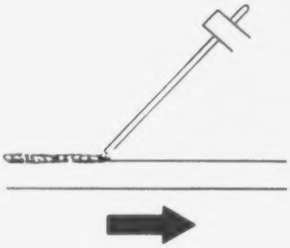


a. ______________________________ b. ______________________________





c. ______________________________ d. ______________________________



e. ______________________________

TEST

5. Discuss the effects of heat on metal.

____

____

____

____

____

6. State guidelines for welding aluminum and high-strength steels.

   a. Aluminum (state four guidelines)

      1) _______________________________________

      2) _______________________________________

      3) _______________________________________

      4) _______________________________________

   b. High-strength steels (state four guidelines)

      1) _______________________________________

      2) _______________________________________

      3) _______________________________________

      4) _______________________________________

7. Select from the following list characteristics of a good weld. Write an "X" in the blank before each correct characteristic.

_____a. Rippled edges

_____b. Smooth edges

_____c. Beveled edges

_____d. Correct bead size

_____e. Elongated bead size

_____f. Flat surface

_____g. Slight crown

_____h. Slight indentation

_____i. Even penetration

_____j. Slight penetration

_____k. Deep penetration

_____l. Clean, bright finish

_____m. Clean, matte finish

TEST

8. State welding safety rules.

   a. General (state eight rules)

      1) ______________________________
      2) ______________________________
      3) ______________________________
      4) ______________________________
      5) ______________________________
      6) ______________________________
      7) ______________________________
      8) ______________________________

   b. Gas welding and cutting (state six rules)

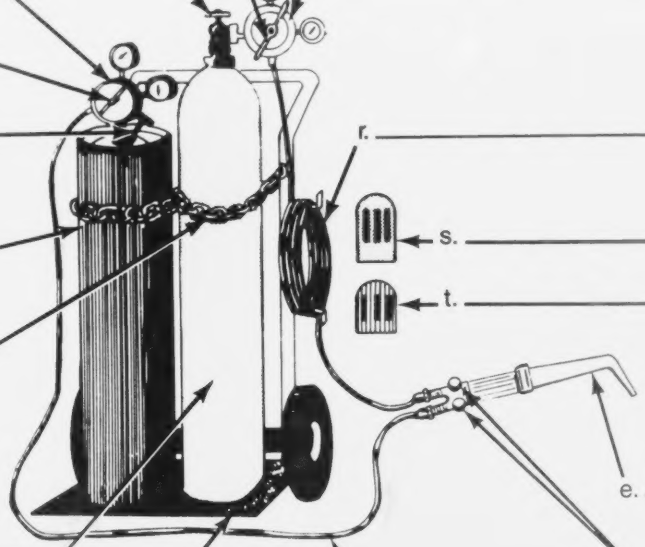
      1) ______________________________
      2) ______________________________
      3) ______________________________
      4) ______________________________
      5) ______________________________
      6) ______________________________

   c. Electric welding (state four rules)

      1) ______________________________
      2) ______________________________
      3) ______________________________
      4) ______________________________

TEST

9. Label the components of the oxyacetylene welding equipment illustrated below.



p. ________________________

o. ________________________

q. ________________________

n. ________________________

m. ________________________

l. ________________________

r. ________________________

s. ________________________

k. ________________________

t. ________________________

j. ________________________

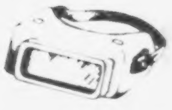
e. ________________________

f. ________________________

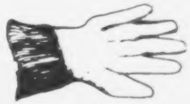
i. ________________________

h. ________________________

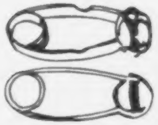
g. ________________________



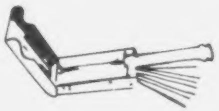
a. ________________________



b. ________________________



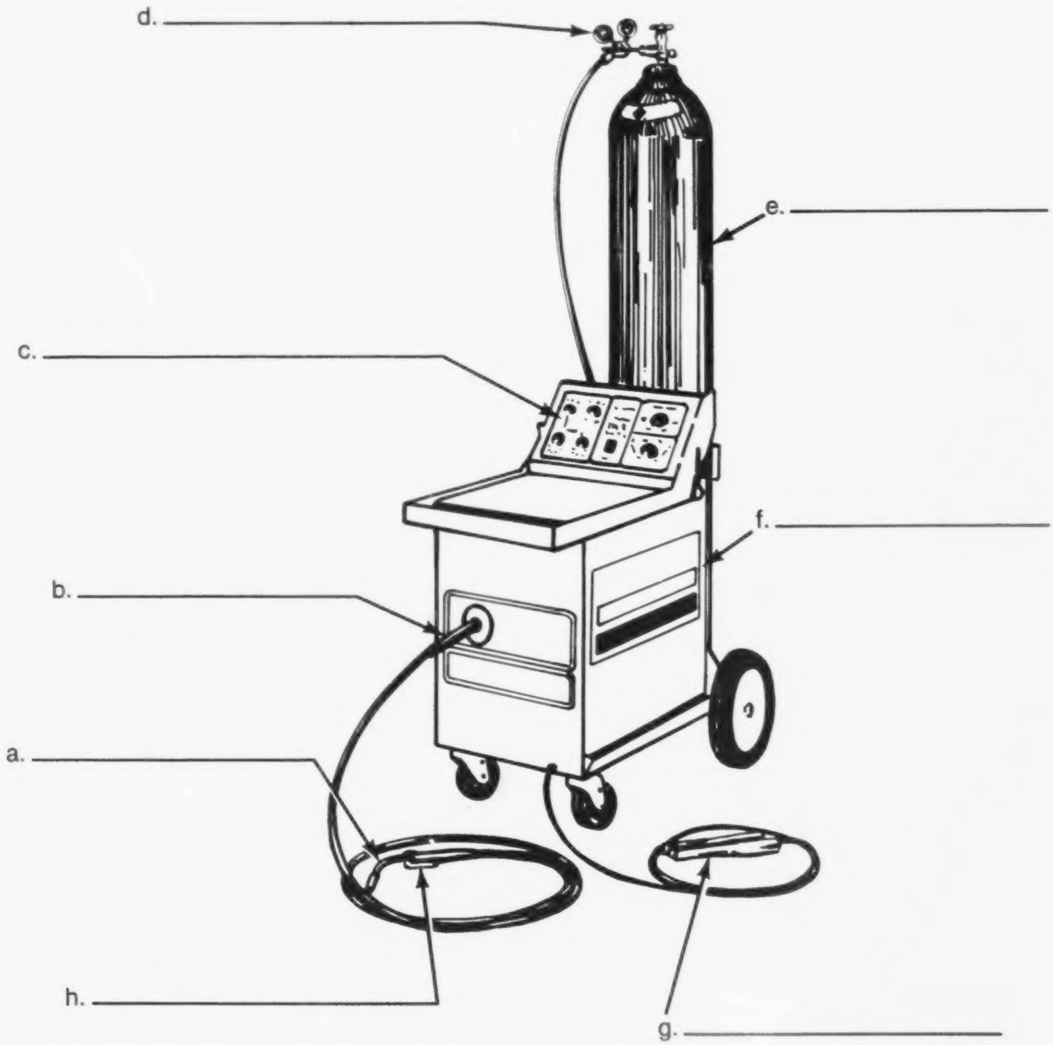
c. ________________________



d. ________________________

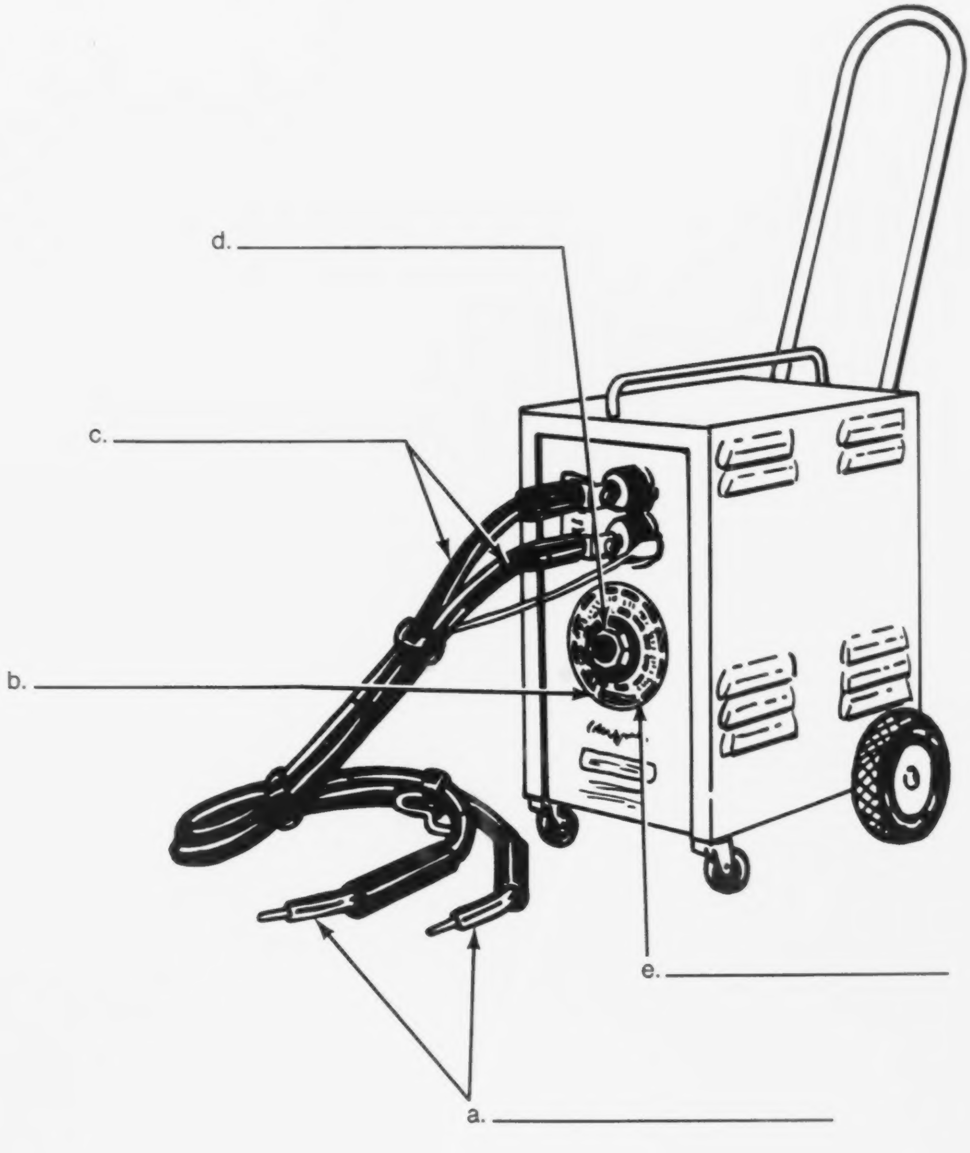
TEST

10. Label components of the metal-inert-gas (MIG) welding equipment illustrated below.



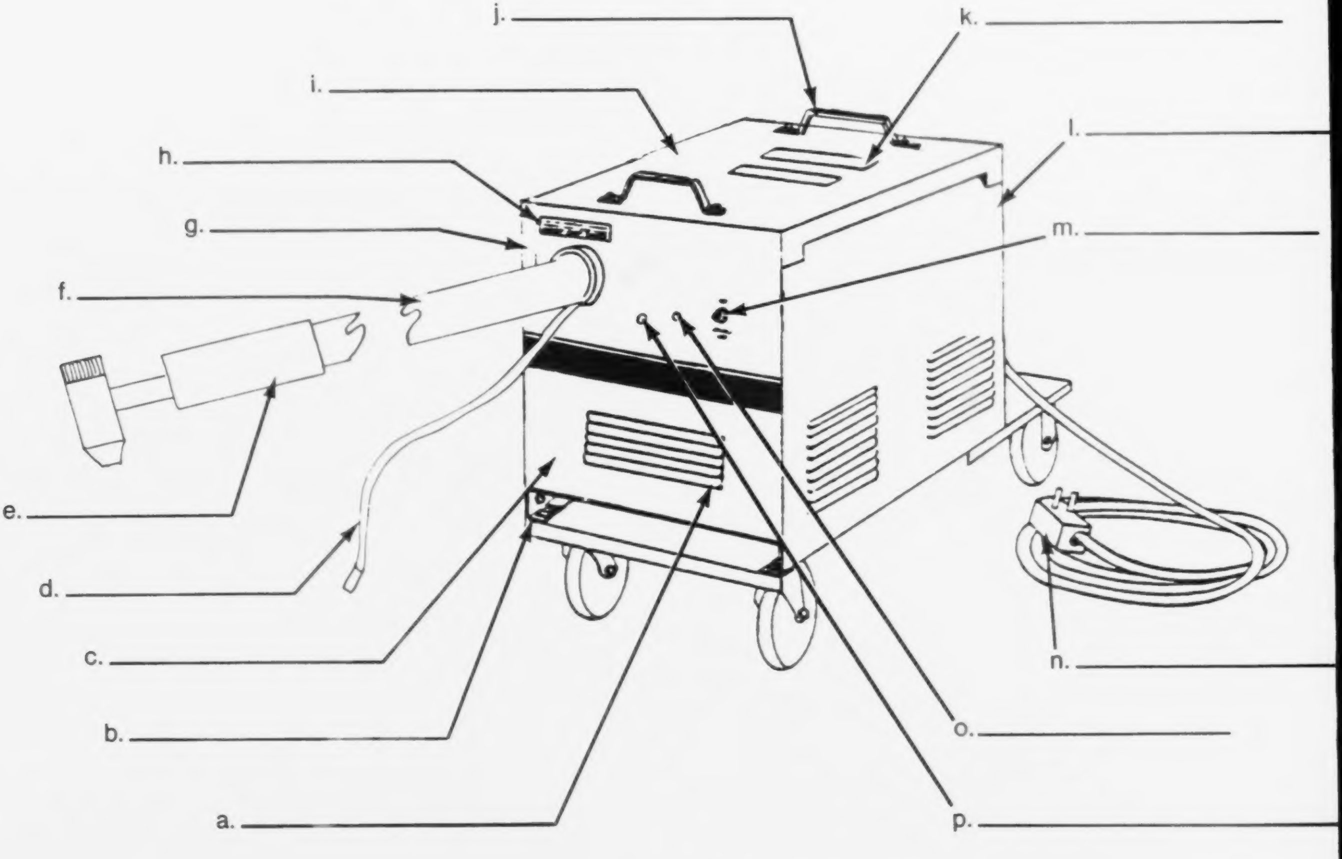
TEST

11. Label components of the resistance spot welding equipment illustrated below.



TEST

12. Label components of the plasma cutting equipment illustrated below.



TEST

(NOTE: Test item 13 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

13. Demonstrate the ability to

    a. Set up oxyacetylene welding equipment.

    b. Set up metal-inert-gas (MIG) welding equipment.

    c. Set up plasma arc cutting equipment.

    d. Perform resistance spot welding.

INTRODUCTION TO WELDING AND CUTTING
UNIT I

ANSWERS TO TEST

1. a. 7
   b. 10
   c. 3
   d. 6
   e. 13
   f. 2
   g. 12
   h. 5
   i. 1
   j. 11
   k. 8
   l. 4
   m. 9
   n. 14

2. a. 3
   b. 1
   c. 2
   d. 6
   e. 4
   f. 7
   g. 5

3. a. Tee (T) joint
   b. Edge joint
   c. Fillet weld
   d. Corner joint
   e. Bead weld
   f. Lap joint
   g. Butt joint
   h. Groove weld
   i. Plug weld
   j. Spot weld

4. a. Vertical up
   b. Horizontal
   c. Overhead
   d. Vertical down
   e. Flat

5. Discussion should include the following

   a. Metal expands when heated
   b. The more heat added, the greater the expansion, and the larger the area affected
   c. Heat softens metal
   d. With continued application of heat, metal will eventually melt
   e. As heated metal cools, it shrinks

6. a. Aluminum (answer should include four of the following)

      1) Use low heat-producing procedures
      2) Thoroughly clean surface to be welded, and use flux to reduce oxide formation

ANSWERS TO TEST

3) Work quickly and keep welding tip moving in small circles to spread heat
4) Direct welding tip so that heat is applied to both weld and adjoining metal
5) Preheat area to be welded
6) Notch joint edges when butt-welding aluminum thicker than ½ inch
7) Because aluminum cools so quickly, avoid buckling the metal when cooling it with water

b. High-strength steels (answer should include four of the following)

1) Use low heat-producing procedures and do not apply heat over the critical temperature
2) Heat only small areas
3) Keep the welding tip moving
4) Apply heat for short periods only
5) Allow heated areas to cool at their own rates
6) Use MIG welding procedures if welding must be done

7. b, d, g, i, l

8. a. General (answer should include any eight of the following)

1) Wear proper protective clothing and eye protection
2) Use equipment and accessories that are in good condition
3) Make sure that a fire extinguisher is available suitable for fires involving materials in the work area
4) Weld only with adequate ventilation
5) Avoid breathing welding fumes
6) Wear welding gloves to handle hot metals
7) Assume as comfortable and unconfined a position as possible, with ready access to welding controls
8) Do not weld on concrete, gravel, or cement
9) Do not weld on or near combustible materials
10) Do not leave welding equipment turned on and unattended
11) Keep work area, equipment, and clothing clean at all times

b. Gas welding and cutting (answer should include any six of the following)

1) Set up cylinders at least 5 feet from welding location
2) Handle cylinders with care, being especially careful to avoid damaging valves and regulators
3) Store cylinders in an upright position and secure with a chain
4) Always use regulators; do not use gases directly from cylinders
5) Never use oil or grease on regulators, fittings, torches, or any surface that may come into contact with compressed oxygen
6) Do not breathe gases—including oxygen—directly from cylinders
7) Use only hoses in good condition and those designated for the gas being used
8) Use soapsuds and a clean paintbrush to test connections and hoses for leaks

ANSWERS TO TEST

9) Do not use acetylene at pressures higher than 15 pounds per square inch (psi)
10) Light torches *only* with proper lighters

c. Electric welding (answer should include any four of the following)

1) Use eye protection when chipping slag
2) Disconnect power before servicing machine
3) When power is on, do not allow electrode holder or gun to come into contact with grounded metal
4) Weld only in a dry area; do not weld while standing on a wet surface
5) Dispose of electrode stubs properly

9. a. Welding goggles
   b. Welding gloves
   c. Flint lighters
   d. Tip cleaners
   e. Torch
   f. Torch valves
   g. Acetylene hose (red)
   h. Cylinder truck
   i. Oxygen cylinder
   j. Safety chain
   k. Acetylene cylinder
   l. Acetylene cylinder valve
   m. Acetylene pressure-regulating screw
   n. Acetylene regulator
   o. Oxygen cylinder valve
   p. Oxygen pressure-regulating screw
   q. Oxygen regulator
   r. Oxygen hose (green)
   s. Oxygen cylinder cap
   t. Acetylene cylinder cap

10. a. Torch gun
    b. Wire-feed system
    c. Timing and control panel
    d. Flowmeter
    e. Shielding gas cylinder
    f. Power supply
    g. Ground clamp
    h. Trigger

11. a. Electrode guns
    b. Zero setting
    c. Dual circuit cables
    d. Amperage and timer control knob
    e. 100 amps maximum current

12. a. Air intake vent
    b. Base
    c. Front panel
    d. Work cable
    e. Torch
    f. Torch power cable
    g. Left side panel
    h. Warning label
    i. Cover
    j. Handle
    k. Warning label
    l. Right side panel
    m. Gas mode switch
    n. Primary power supply line
    o. Pilot light
    p. Power switch

13. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to set up, light, adjust, and use an oxyacetylene outfit. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with oxyacetylene processes.
2. State the color codes for oxygen and acetylene hoses.
3. Identify types of oxyacetylene flames.
4. Distinguish between flashback and backfire.
5. Arrange in order steps to follow in case of flashback.
6. Select from a list the causes of backfire.
7. List factors to consider in selecting filler rods and welding tips.
8. List the purpose of flux.
9. List the purposes of braze welding filler rod composition.
10. Identify the parts of a torch body and cutting attachment.
11. Match common cutting-torch tips to their correct uses.
12. Demonstrate the ability to
    a. Lay beads on light-gauge metal without filler rod.
    b. Lay beads on light-gauge metal with filler rod.
    c. Weld a butt joint with filler rod.
    d. Braze-weld a square-groove butt joint.
    e. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.
    f. Cut mild steel at a 90-degree angle, stop, and restart the cut.

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Transparency masters

      1. TM #1 — Oxygen Regulator Gauges

      2. TM #2 — Acetylene Regulator Gauges

   D. Information sheet

   E. Job sheets

      1. Job Sheet #1 — Lay Beads on Light-Gauge Metal Without Filler Rod

      2. Job Sheet #2 — Lay Beads on Light-Gauge Metal with Filler Rod

      3. Job Sheet #3 — Weld a Butt Joint with Filler Rod

      4. Job Sheet #4 — Braze-Weld a Square-Groove Butt Joint

      5. Job Sheet #5 — Turn On, Light, Adjust to a Neutral Flame, and Turn Off Oxyacetylene Cutting Equipment

      6. Job Sheet #6 — Cut Mild Steel at a 90-Degree Angle, Stop, and Restart the Cut

   F. Test

   G. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Obtain or order materials to supplement unit.

      1. Equipment and materials for job sheet procedures

      2. Color flame charts from welding supplier to show types of flames

      3. Materials on cutting, welding, and brazing techniques; pressurized gas; safety equipment; and other items of interest

SUGGESTED ACTIVITIES

4. Films

   a. *Braze Welding* and *Flame-Cutting*

      (NOTE: These films are available on a free-loan basis to Oklahoma teachers, Oklahoma teachers may order from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074. Out-of-state teachers must order from MacMillian Films, 34 MacQuesten Parkway South, Mount Vernon, New York 10550, 914/664-5051.)

   b. *Don't Push Your Luck*

      (NOTE: In this film, Bill Frank, an actual victim, recreates his real-life blinding accident. He delivers to employees a powerful safety message on face and eye protection. The film is available from Harvest Films, Inc., 309 5th Avenue, New York, New York 10016. 212/648-7950.)

5. Slide/cassette programs and filmstrips

   a. *There's Something in the Air*, thirty slides with cassette

      (NOTE: This slide/tape presentation is available from the National Safety Council, P.O. Box 11933, Chicago, Illinois 60611, 312/527-4800.)

   b. *Oxyacetylene Cutting Explained*, 2 color filmstrips, 2 cassettes, 12 to 13 minutes each

      (NOTE: These filmstrips may be purchased from Bergwall Productions, Inc., 839 Steward Avenue, P.O. Box 238, Garden City, New York 11530.)

6. Transparencies and competency profiles

   (NOTE: Transparencies and competency profiles for this book are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit by pointing out the versatility of the oxyacetylene outfit for various types of metal construction and repair.

   SUGGESTIONS:

   - Give examples of the uses of the oxyacetylene processes in auto-body repair.
   - Explain that people skilled in oxyacetylene welding obtain well-paying jobs and can save money by making their own welding repairs and projects.

SUGGESTED ACTIVITIES

- Emphasize that the major thrust of the unit is to learn how to use oxyacetylene welding, brazing, and cutting equipment safely and skillfully.
- Discuss unit and specific objectives, pointing out the main emphasis of each objective and explaining how the specific objectives lead to accomplishment of the unit objective.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I and an actual oxyacetylene outfit to introduce students to terms and definitions associated with oxyacetylene processes.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss color codes for oxygen and acetylene hoses. Also discuss the characteristics of these gases.

   SUGGESTIONS:

   - Release some oxygen into the classroom air to show students that oxygen is colorless and odorless.
   - Perform the following demonstration to emphasize that oxygen supports and intensifies combustion:
     a. Position a small burning candle on a table.
     b. Set a glass container over the candle; the candle will burn out when the oxygen trapped in the container is used up.
     c. Relight the candle.
     d. Fill the container with oxygen from the torch, maintaining as good a seal as possible with your hand.
     e. Quickly set the oxygen-filled container down over the lighted candle to illustrate how the high concentration of oxygen intensifies the flame.

3. Use Information Sheet, Section III and actual torch flames to discuss and demonstrate the types of oxyacetylene flames.

   SUGGESTIONS:

   - Show films on flame cutting and brazing.
   - Explain how to recognize the different oxyacetylene flames and how to adjust the torch to the desired flame.
   - After demonstrating how to adjust the lighted torch to the various types of flames, allow each student to adjust the lighted torch.

SUGGESTED ACTIVITIES

4. Use Information Sheet, Sections IV through VI to discuss flashback and backfire.

   SUGGESTIONS:

   - Before they are allowed to operate a torch, require students to know the correct order of the steps to follow in case of flashback.
   - Explain the logic of the steps as they are performed.
   - Remind the students that check valves become a valuable investment in the event of flashback.
   - Discuss causes of backfire. Stress that should a torch backfire, the problem must be analyzed and corrected before continued use. Stress to students that even if they, as operators, are at fault, backfire must be reported to the instructor immediately so that corrections can be made.

5. Use Information Sheet, Section VII to discuss selection of filler rods and welding tips.

   SUGGESTIONS:

   - Show sample tips and demonstrate how to install and use them.
   - Emphasize uses in the auto-body trade for specific rods and tips for particular metals.

6. Use Information Sheet, Section VIII to discuss the purposes of flux.

7. Use Information Sheet, Section IX to discuss the purposes of braze welding filler rod composition.

8. Use Information Sheet, Sections X and XI to introduce students to the parts of a torch body and cutting attachment and to common cutting tips and their correct uses.

   SUGGESTIONS:

   - Assemble this equipment so that you can demonstrate how the equipment is put together as each part is explained.
   - Relate cutting tip uses to auto-body repair jobs.
   - Demonstrate and explain Job Sheets #1 through #6. Assign completion dates, and allow students to practice until they have mastered each skill.
   - Use Transparencies #1 and #2 and actual gauges to acquaint students with oxygen and acetylene gauges.

SUGGESTED ACTIVITIES

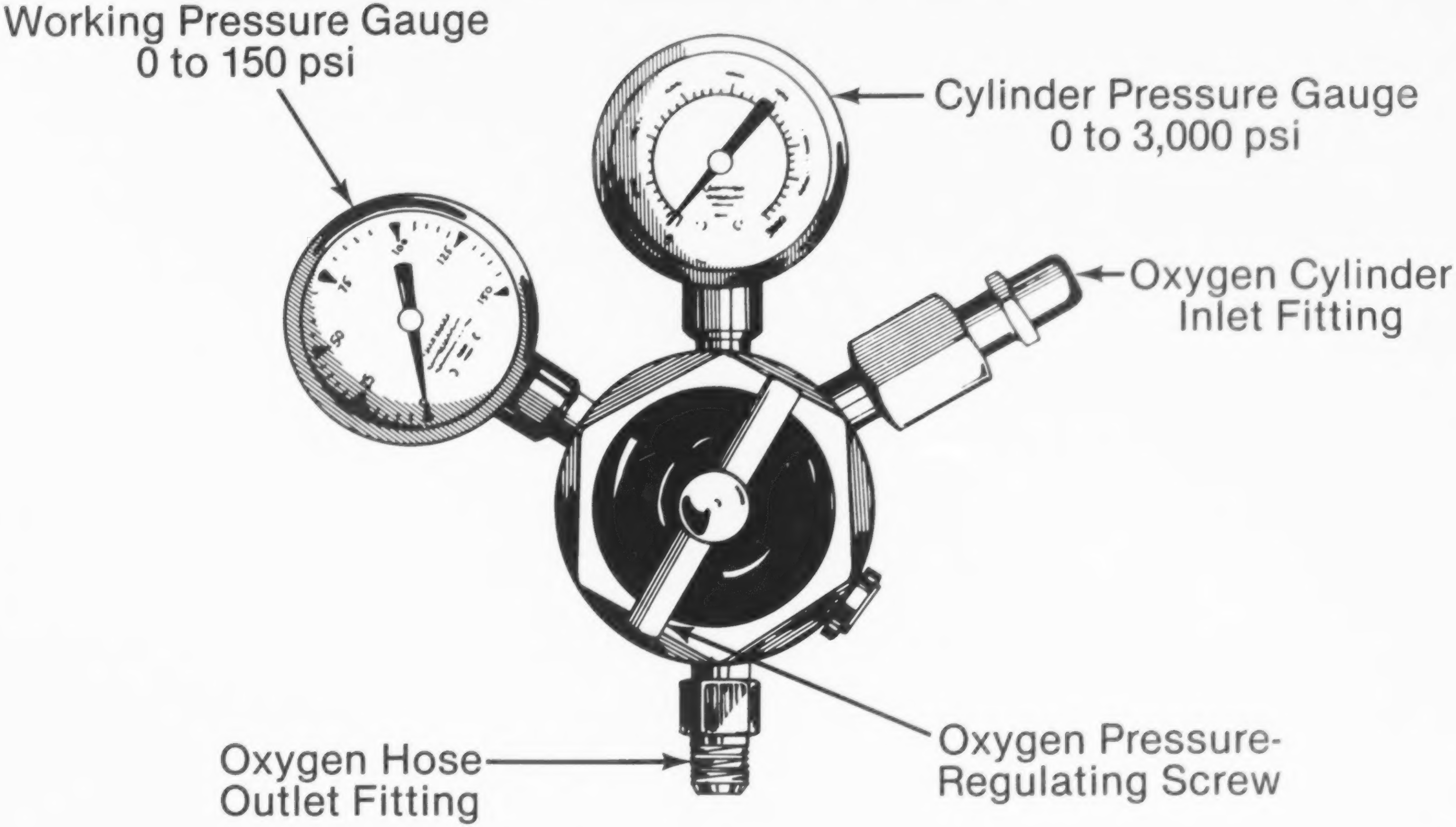
F. Review unit and give test.

G. Critique test and discuss in class.

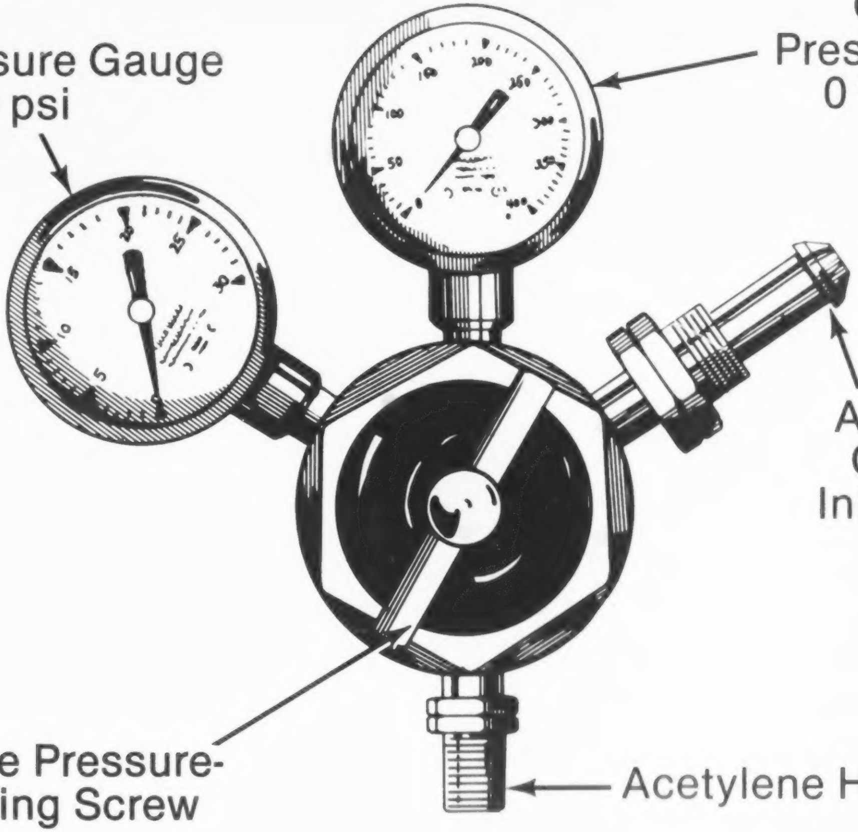
H. Complete appropriate section of competency profiles.

III. Unit reference — Hendrix, Laborn J., "Bud." *Commercial Carpentry*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1986.

Oxygen Regulator Gauges



Acetylene Regulator Gauges



Working Pressure Gauge
0 to 30 psi

Cylinder
Pressure Gauge
0 to 400 psi

Acetylene
Cylinder
Inlet Fitting

Acetylene Pressure-
Regulating Screw

Acetylene Hose Outlet Fitting

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Acetylene — Colorless, gas with characteristic odor

      (NOTE: Other gases are also used in cutting.)

   B. Oxygen — Element that is normally a colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding

   C. Oxyacetylene cutting — Flame-cutting of metal in which metal is preheated with a flame produced by an oxyacetylene torch

   D. Purge — To remove any foreign material from a system or component by flushing with the gas used in that system

   E. psi — Pounds per square inch

   F. Combustible — Capable of burning

   G. Toxic — Poisonous

   H. Torch lighter — Striker used to ignite torch

   I. Slag — Metal that melts away during oxyacetylene cutting process

II. Color codes for oxygen and acetylene hoses

   A. Oxygen — Green

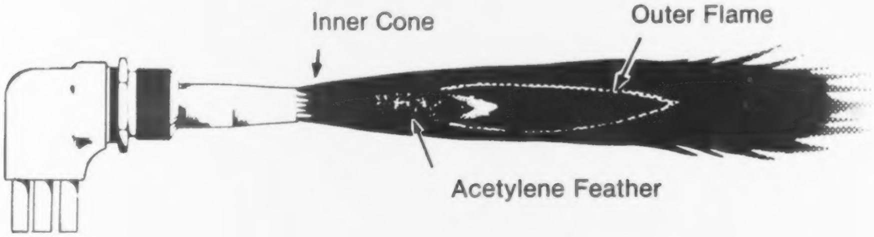
   B. Acetylene — Red

III. Types of oxyacetylene flames (Figures 1-3)

   A. Carburizing flame

      (NOTE: The flame illustrated has an excess of acetylene gas.)

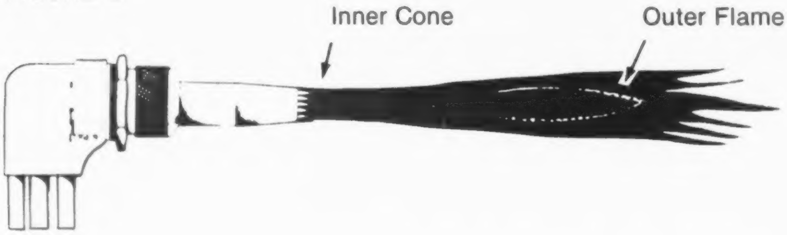
FIGURE 1



B. Neutral flame

(NOTE: The flame illustrated has the proper ratio of oxygen to acetylene.)

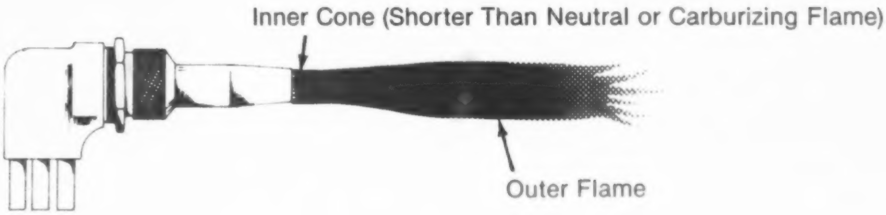
FIGURE 2



C. Oxidizing flame

(NOTE: The flame illustrated has an excess of oxygen.)

FIGURE 3



IV. Differences between flashback and backfire

A. Flashback — Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip

B. Backfire — Flame burns momentarily back into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

INFORMATION SHEET

V. Sequence of steps to follow in case of flashback

(NOTE: Flashback is a very dangerous condition and should be corrected immediately.)

- A. Close oxygen torch valve
- B. Close acetylene torch valve
- C. Release oxygen pressure-regulating screw
- D. Release acetylene pressure-regulating screw
- E. Examine oxyacetylene unit
- F. Reset regulator pressures
- G. Light torch

  (NOTE: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen and acetylene cylinders, and then notify the supervisor.)

VI. Causes of backfire

(NOTE: The causes listed below should be carefully checked to control backfire.)

- A. Not enough acetylene or oxygen pressure for the tip size used
- B. Loose cutting tip
- C. Dirty tip

  (NOTE: The tip may have deposits or metal particles inside the orifice. These deposits may overheat and act as ignitors.)
- D. Overheating of cutting tip
- E. Bad O-ring in torch body

VII. Factors to consider in selecting filler rods and welding tips

- A. Thickness of base metal

  (NOTE: A general rule is to use a rod the same thickness as the base metal and to use the tip size recommended by the rod manufacturer for that size rod.)
- B. Properties of base metal

  (NOTE: The rod should have properties similar to the base metal, and the tip should be appropriate for the rod.)

INFORMATION SHEET

VIII. Purposes of flux

A. Chemically cleans base metal

B. Prevents oxidation of filler metal

C. Floats and removes oxides already present

D. Increases flow of filler metal

E. Increases ability of filler metal to adhere to base metal

F. Brings filler metal into immediate contact with metals being joined

G. Permits filler metal to penetrate pores of base metal

IX. Purposes of braze welding filler rod composition

(NOTE: Braze welding filler rods are composed primarily of copper and zinc. However, they may also contain traces of tin, iron, manganese, and silicon. There materials produce the desired characteristics.)

A. Provides increased strength

B. Increases ductility

(NOTE: Ductility is the property of a material to stretch without breaking.)

C. Deoxidizes weld metal

(NOTE: Oxidation is a chemical build-up on metal, an extreme example being rust. In braze welding, the joined surfaces must be free of foreign materials such as oxidation.)

D. Decreases fuming

(NOTE: Fuming is the smoking and spattering that occurs during welding.)

E. Increases free-flowing action of molten metal

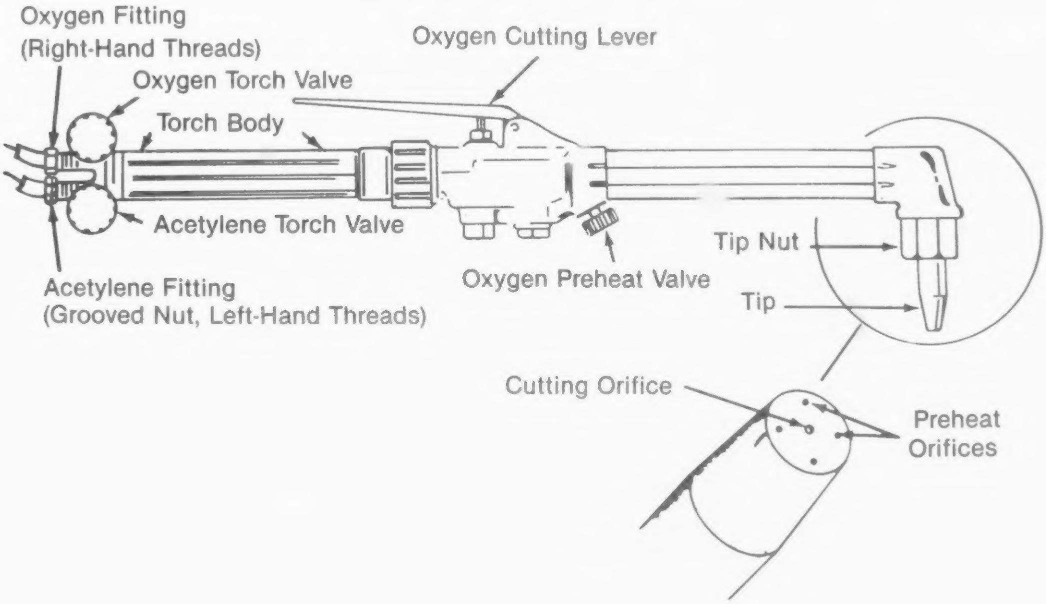
F. Increases hardness of deposited metal

INFORMATION SHEET

X. Parts of a torch body and cutting attachment (Figure 4)

(NOTE: The preheat orifices heat metal to a kindling point of approximately 1,600°F [755°C]. The cutting orifice removes oxidized metal.)

FIGURE 4

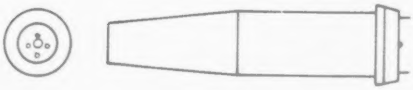


XI. Common cutting-torch tips and their uses (Figures 5-8)

(NOTE: Most of the following cutting tips are available in two or more sizes and should be selected on the basis of the thickness of the metal to be cut and the job to be performed.)

A. Straight-line or shape cutting of clean plate

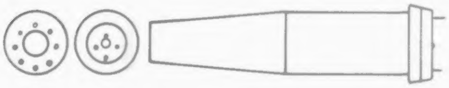
FIGURE 5



INFORMATION SHEET

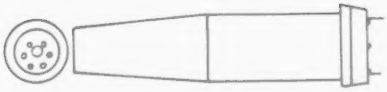
B. Cutting rusty or painted surfaces

FIGURE 6



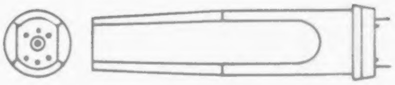
C. General cutting

FIGURE 7



D. Grooving

FIGURE 8



OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

JOB SHEET #1 — LAY BEADS ON LIGHT-GAUGE METAL WITHOUT FILLER ROD

I. Equipment and materials

A. Oxyacetylene welding unit and welding tip recommended by manufacturer

B. Welding gloves

C. Protective clothing and eye protection

D. Pliers

E. Wire brush

F. Flint lighter

G. Firebricks

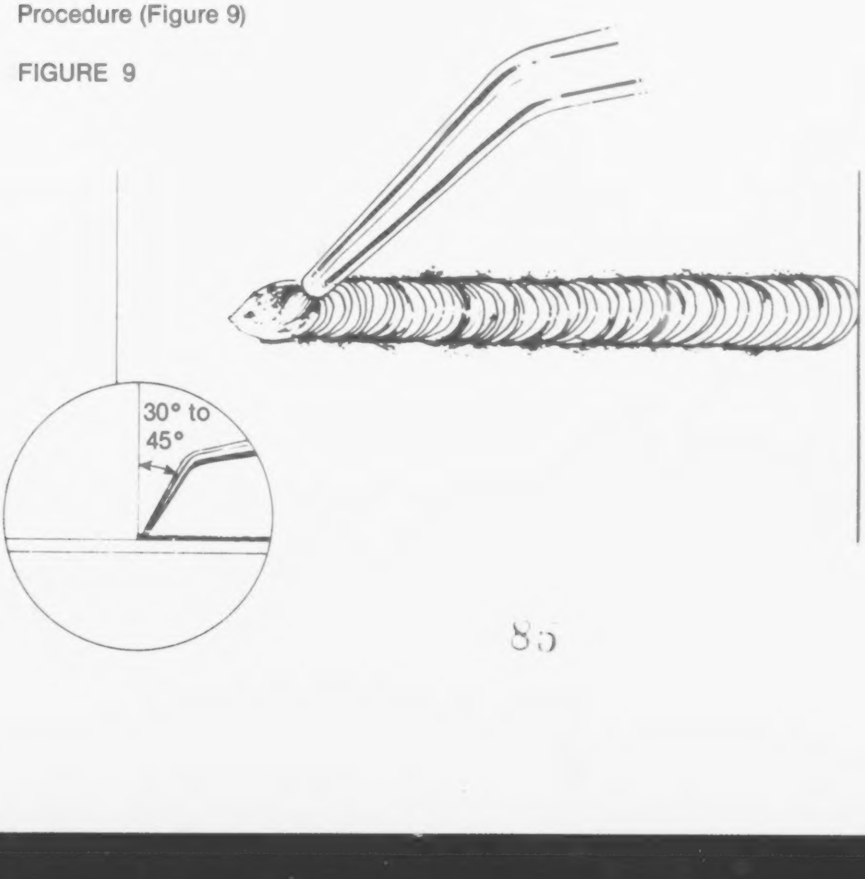
H. Mild steel plate

I. Foam or multipurpose dry-chemical fire extinguisher

J. Tip cleaners

II. Procedure (Figure 9)

FIGURE 9



JOB SHEET #1

A. Put on protective clothing and eye protection

B. Prepare metal for welding

C. Place metal on firebricks in welding position

D. Turn on oxyacetylene unit

E. Set working pressure according to manufacturer's recommendations

F. Light torch and adjust to a neutral flame

G. Place inner cone about 1/16 inch to 1/8 inch from metal

H. Hold torch 30 degrees to 45 degrees from vertical in direction of travel

(NOTE: Do not begin travel until you have established a molten puddle.)

I. Slowly move torch forward in a circular or back-and-forth motion, allowing metal to melt

J. Repeat process until instructor gives permission to go on to next job

K. Clean work area and return equipment and materials to proper storage

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

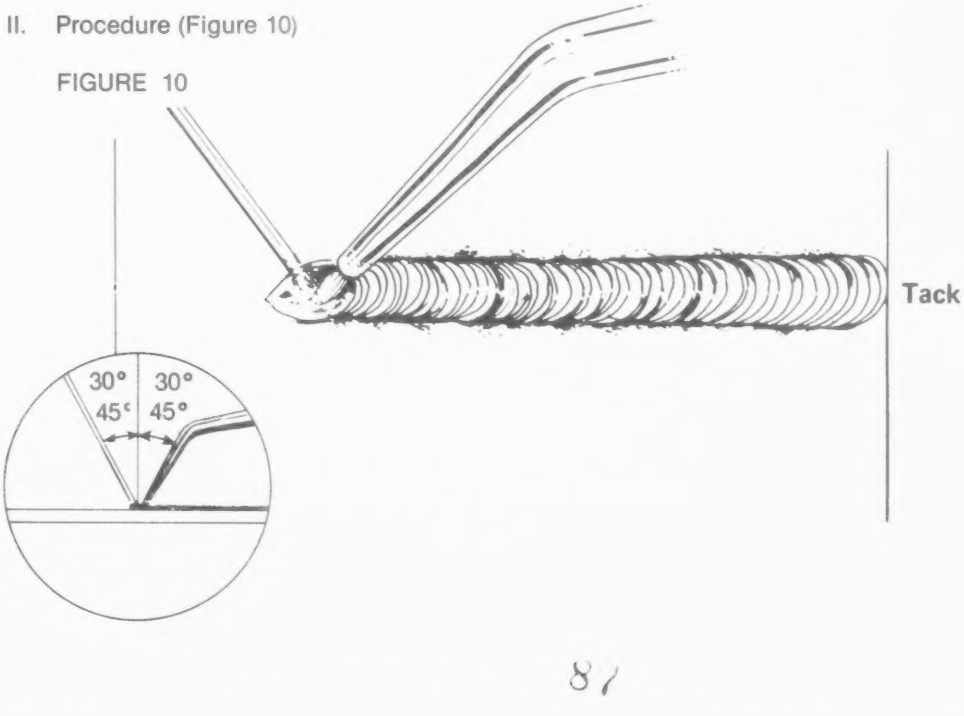
JOB SHEET #2 — LAY BEADS ON LIGHT-GAUGE METAL WITH FILLER ROD

I. Equipment and materials

- A. Oxyacetylene welding unit and welding tip recommended by manufacturer
- B. Welding gloves
- C. Protective clothing and eye protection
- D. Pliers
- E. Wire brush
- F. Flint lighter
- G. Firebricks
- H. Light-gauge mild steel
- I. Filler rod mild steel recommended by manufacturer
- J. Foam or multipurpose dry-chemical fire extinguisher
- K. Tip cleaners

II. Procedure (Figure 10)

FIGURE 10



JOB SHEET #2

A. Put on protective clothing and eye protection

B. Prepare metal for welding

C. Place metal on firebricks in welding position

D. Turn on oxyacetylene unit

E. Set working pressure according to manufacturer's recommendation

F. Light torch and adjust to a neutral flame

G. Hold torch 30 degrees to 45 degrees from vertical in direction of travel

H. Place inner cone about $^{1}/_{16}$ inch to $^{1}/_{8}$ inch from surface of puddle

(NOTE: Do not begin travel until you have established a molten puddle.)

I. Add filler rod to front edge of puddle in front of torch

J. Move puddle forward with torch and allow puddle to form in base metal

K. Add rod and withdraw rod to front edge of puddle as you move puddle forward

(NOTE: Keep puddle the same size and shape the entire length of the bead.)

L. Show bead to instructor when completed

M. After laying bead, practice welding various joints

N. Clean work area and return equipment and materials to proper storage

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

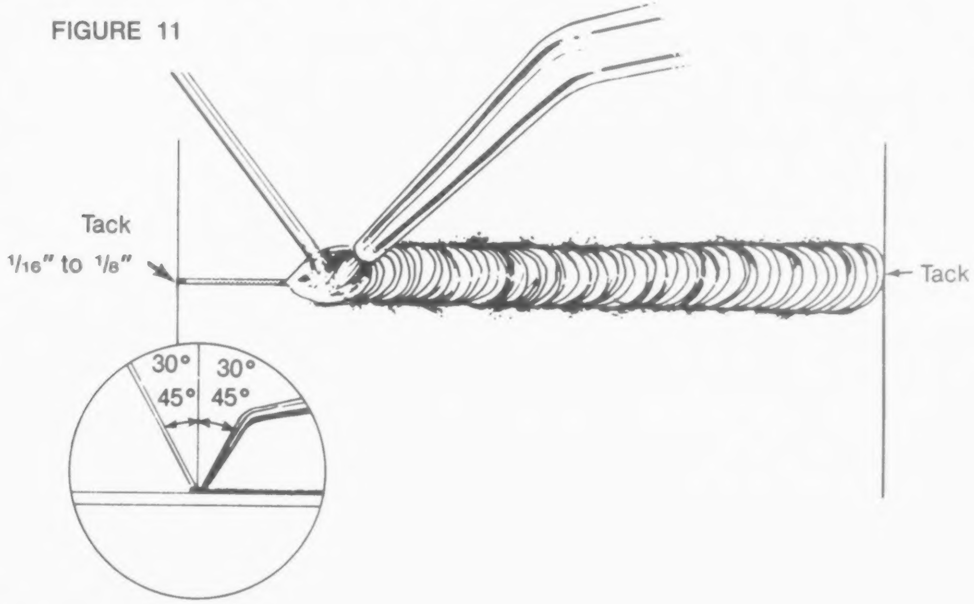
JOB SHEET #3 — WELD A BUTT JOINT WITH FILLER ROD

I. Equipment and materials

- A. Oxyacetylene welding unit and welding tip recommended by manufacturer
- B. Welding gloves
- C. Protective clothing and eye protection
- D. Pliers
- E. Wire brush
- F. Flint lighter
- G. Firebricks
- H. Two pieces of mild steel plate
- I. Filler rod mild steel recommended by manufacturer
- J. Foam or multipurpose dry-chemical fire extinguisher
- K. Tip cleaners

II. Procedure (Figure 11)

FIGURE 11



JOB SHEET #3

A. Put on protective clothing and eye protection

B. Place metal on firebricks in welding position, $^1/_{16}$- to $^1/_8$-inch apart

C. Turn on oxyacetylene unit

D. Set working pressure according to manufacturer's recommendation

E. Light torch and adjust to a neutral flame

F. Tack-weld metal together every 1 to 2 inches

G. Hold torch 30 degrees to 45 degrees from vertical

H. Place inner cone about $^1/_{16}$ inch to $^1/_8$ inch from surface of puddle

(NOTE: Do not begin travel until you have established a molten puddle.)

I. Add filler rod to front edge of puddle in front of torch

J. Move puddle forward with torch and allow puddle to form in base metal

K. Add rod and withdraw rod to front edge of puddle as you move puddle forward

(NOTE: Keep puddle the same size and shape the entire length of the bead.)

L. After laying bead, practice welding various joints

M. Clean work area and return equipment and materials to proper storage

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

JOB SHEET #4 — BRAZE-WELD A SQUARE-GROOVE BUTT JOINT

I. Equipment and materials

A. Oxyacetylene welding unit and welding tip recommended by manufacturer

B. Welding gloves

C. Protective clothing and eye protection

D. Wire brush

E. Flint lighter

F. Firebricks

G. Two pieces of mild steel plate

H. Bronze filler rod recommended by manufacturer

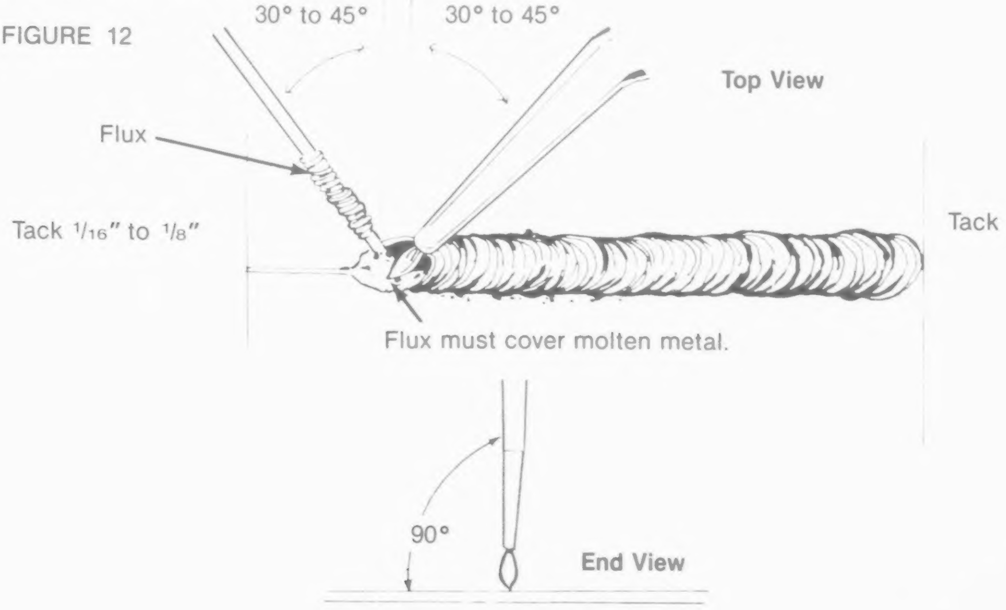
I. Welding flux (or fluxed rod)

J. Foam or multipurpose dry-chemical fire extinguisher

K. Tip cleaners

II. Procedure (Figure 12)

FIGURE 12



JOB SHEET #4

A. Put on protective clothing and eye protection

B. Clean metal to prepare for brazing

C. Place metal plates on firebrick, arranging plates in brazing position, $^1/_{16}$ inch to $^1/_8$ inch apart

D. Turn on oxyacetylene unit

E. Adjust working pressure of oxygen and acetylene according to manufacturer's recommendations

F. Light torch and adjust to a neutral or slightly oxidized flame

G. Preheat end of brazing rod and dip into flux (or use fluxed rod)

H. Tack-weld metal in place every 1 to 2 inches, using brazing filler metal

I. Heat surface of weld slightly

J. Hold torch 30 degrees to 45 degrees from vertical; hold filler rod at same angle in opposite direction (See Figure 15)

K. When a dull, cherry-red color occurs, melt small amount of brazing rod onto surface and allow it to spread along entire seam in the process known as *tinning*

L. When base metal is tinned sufficiently, start depositing proper size bead

M. Watch base metal color and reaction

(NOTE: When metal is not hot enough, the brazing rod bronze forms into drops; when metal is too hot, the bronze boils and releases excessive white smoke.)

N. Show bead to instructor when completed

O. Clean work area and return equipment and materials to proper storage

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

JOB SHEET #5 — TURN ON, LIGHT, ADJUST TO A NEUTRAL FLAME, AND TURN OFF OXYACETYLENE CUTTING EQUIPMENT

I. Equipment and materials

A. Oxyacetylene cutting outfit with tip assembly

B. Wrench

C. Welding gloves

D. Welding goggles

E. Coveralls or protective clothing free of oil and grease

F. Flint lighter

G. Foam or multipurpose dry-chemical fire extinguisher

H. Tip cleaners

II. Procedure

A. Put on protective clothing and eye protection

B. Check all cylinder, regulator, and torch valves to make sure that they are closed

C. Clean tip

(NOTE: Clean tip before lighting torch and as often as needed.)

D. Open acetylene cylinder valve one-quarter to one-half turn

CAUTION

Never open cylinder valve more than one and one-half turns.

E. Open acetylene valve on torch one turn

F. Turn acetylene pressure-regulating screw clockwise until desired pressure is reached

(NOTE: Oxygen and acetylene pressures and size of tip depend upon the thickness of the metal to be cut. Use pressure and tip size recommended by manufacturer.)

JOB SHEET #5

CAUTION

Acetylene becomes unstable and highly explosive at pressures higher than 15 psi.

G. Close acetylene valve on torch

H. Open oxygen cylinder valve all the way

I. Open oxygen torch valve all the way

J. Open oxygen preheat valve on cutting attachment one turn

K. Turn oxygen pressure-regulating screw clockwise until desired pressure is reached (Table 1)

(NOTE: Most cutting-tip manufacturers will recommend a range of at least three sizes for any cutting condition. One end of the range gives the most economy; the other end gives the maximum speed. For the learner, the middle size is usually the best. Table 1 is for a torch tip that provides four preheat orifices. For heavier or faster cutting, a tip that provides 6, 8, 10, or 12 preheat orifices may be used.)

TABLE 1

Metal Thickness in Inches	Preheat Orifice Drill Size	Cutting Orifice Drill Size	Oxygen Pressure (psi)	Acetylene Pressure (psi)	Speed in Inches per Minute
1/8 to 3/8	70	67	20 to 30	3	14 to 18
3/8 to 3/4	58	62	30 to 40	5	12 to 15
3/4 to 1	57	54	40 to 45	5	10 to 12
1 1/2 to 2	68	51	45 to 50	5	9 to 10

L. Close oxygen preheat valve on cutting attachment

M. Open acetylene valve on torch one-quarter turn

N. Light torch with flint lighter and adjust until smoke on flame clears

O. Open oxygen preheat valve slowly and adjust to a neutral flame

P. Depress oxygen cutting lever; and check to see that a neutral flame is present

(NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until and a neutral flame is secured. Pressure rises slightly when the valve is closed.)

JOB SHEET #5

Q. Shut down equipment

1. Close acetylene valve on torch
2. Close acetylene cylinder valve
3. Close oxygen preheat valve
4. Close oxygen cylinder valve
5. Open acetylene valve on torch
6. When gauges reach zero, close torch valve, and release acetylene pressure-regulating screw by turning counterclockwise
7. Open oxygen preheat valve on torch
8. When gauges reach zero, close oxygen preheat valve, and turn oxygen pressure-regulating screw counterclockwise
9. Close oxygen valve on torch

R. Place torch and hose on hanger or brackets provided

(NOTE: If regulators are removed from cylinders, replace the caps.)

S. Clean work area and return equipment and materials to proper storage

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

JOB SHEET #6 — CUT MILD STEEL AT A 90-DEGREE ANGLE, STOP, AND RESTART THE CUT

I. Equipment and materials

- A. Oxyacetylene cutting outfit with tip assembly
- B. Mild steel
- C. Soapstone with a sharp point or edge
- D. Straightedge
- E. Pliers
- F. Protective clothing and eye protection
- G. Flint lighter
- H. Welding or cutting table
- I. Can of water
- J. Foam or multipurpose dry-chemical fire extinguisher
- K. Tip cleaners

II. Procedure

- A. Put on protective clothing and eye protection
- B. Mark four parallel lines 2 inches apart on plate to be cut
- C. Clean tip

  (NOTE: Clean tip before lighting torch and as often as needed.)
- D. Turn on oxyacetylene outfit
- E. Adjust oxygen regulator
- F. Adjust acetylene regulator
- G. Light torch with flint lighter
- H. Adjust to neutral flame

JOB SHEET #6

I. Place hoses behind you

J. Assume comfortable position

K. Maneuver torch as required

(NOTE: Sometimes you must use both hands to hold torch steady for a straight cut.)

L. Hold preheat flame with tip of inner cone 1/16 inch to 1/8 inch above top of plate at right edge until red spot appears

CAUTION

Burning metal flames and sometimes sparks, creating the danger of burns.

M. Depress oxygen cutting lever and move from right to left across the plate

(NOTE: Left-handed operators move from left to right.)

N. Hold tip at correct angle to work for thickness of metal, while cutting with inner cone approximately 1/16 inch above work

(NOTE: The thicker the metal, the closer to a right angle the tip should be held.)

O. Make 90-degree cuts until you have developed the proper procedure

P. Cool metal by placing in can of water with the aid of pliers

Q. Restart a cut

1. Release oxygen cutting lever
2. Preheat only the edge where cutting action was stopped
3. Depress oxygen cutting lever slowly and continue cut

R. Turn off oxyacetylene outfit

S. Clean work area, and return equipment and materials to proper storage

ABR - 93-A

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with oxyacetylene processes. Write the correct numbers in the blanks.

   ______a. Colorless, gas with characteristic odor

   ______b. Element that is normally colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding

   ______c. Flame-cutting of metal in which metal is preheated with a flame produced by an oxyacetylene torch

   ______d. Pounds per square inch

   ______e. Striker used to ignite torch

   ______f. Metal that melts away during oxyacetylene cutting process

   ______g. To remove any foreign material from a system or component by flushing with the gas used in that system

   ______h. Capable of burning

   ______i. Poisonous

   1. Combustible
   2. Oxygen
   3. Acetylene
   4. Slag
   5. Toxic
   6. Oxyacetylene cutting
   7. Purge
   8. Torch lighter
   9. psi

2. State the color codes for oxygen and acetylene hoses.

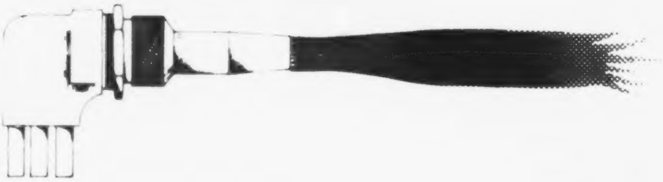
   a. Oxygen — ______________________________

   b. Acetylene — ______________________________

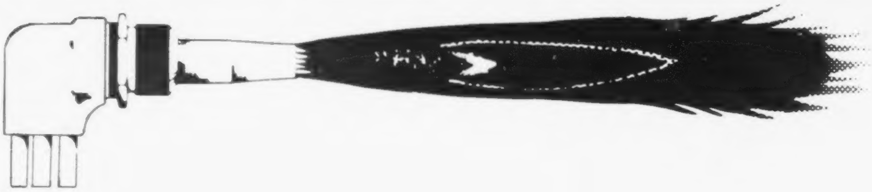
TEST

3. Identify the types of oxyacetylene flames illustrated below. Write the correct names in the blanks.

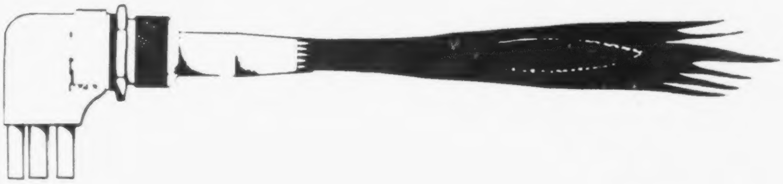
Carburizing flame **Neutral flame** **Oxidizing flame**



a. ____________________



b. ____________________



c. ____________________

4. Distinguish between flashback and backfire. Write an "F" in the blank before flashback and a "B" in the blank before backfire.

_____a. Flame burns momentarily into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

_____b. Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip

TEST

5. Arrange in order steps to follow in case of flashback. Write a "1" before the first step, a "2" before the second step, and so on.

______a. Light torch

______b. Release oxygen pressure-regulating screw

______c. Reset regulator pressures

______d. Close oxygen torch valve

______e. Release acetylene pressure-regulating screw

______f. Close acetylene torch valve

______g. Examine acetylene unit

6. Select from the following list causes of backfire. Write an "X" in the blank before each correct answer.

______a. Too much oxygen

______b. Not enough acetylene or oxygen pressure for the tip size used

______c. Too much acetylene

______d. Loose cutting tip

______e. Overheating of cutting tip

______f. Bad O-ring in torch body

______g. Dirty tip

7. List factors to consider in selecting filler rods and welding tips.

a. ____

b. ____

8. List five purposes of flux.

a. ____

b. ____

c. ____

d. ____

e. ____

TEST

9. List four purposes of braze welding filler rod composition.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

10. Identify the parts of the torch body and cutting attachment illustrated below. Write the correct numbers in the blanks.

    _____a. Acetylene fitting (grooved nut, left-hand threads)

    _____b. Cutting orifice

    _____c. Oxygen fitting (right-hand threads)

    _____d. Tip nut

    _____e. Oxygen preheat valve

    _____f. Preheat orifices

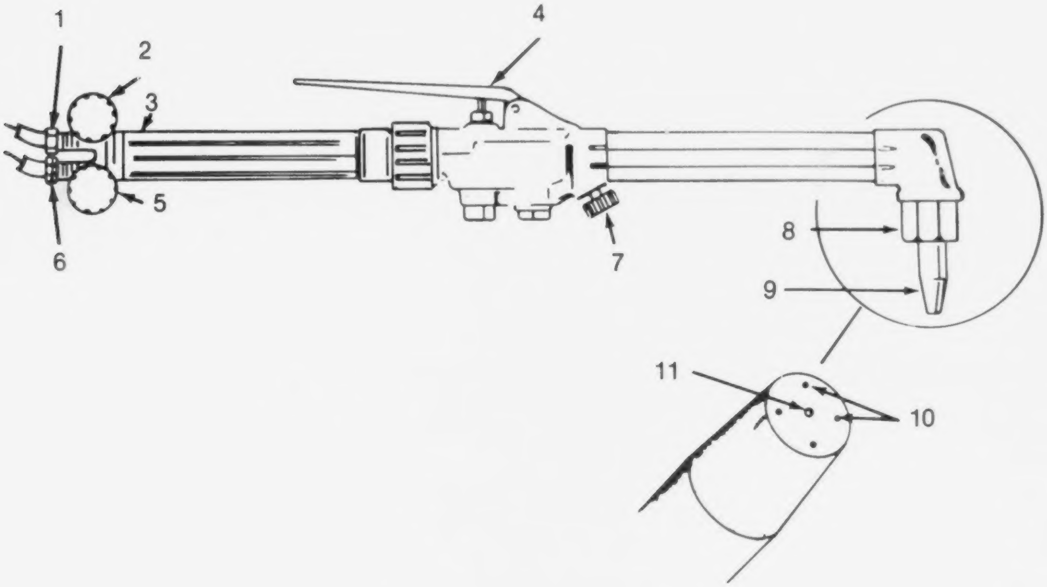
    _____g. Oxygen torch valve

    _____h. Tip

    _____i. Oxygen cutting lever

    _____j. Torch body

    _____k. Acetylene torch valve



TEST

11. Match common cutting-torch tips to their correct uses. Write the correct numbers in the blanks.

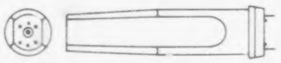
_____a. General cutting

_____b. Straight-line or shape cutting of clean plate

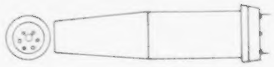
_____c. Grooving

_____d. Cutting rusty or painted surfaces

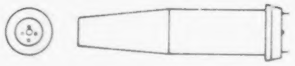
1.



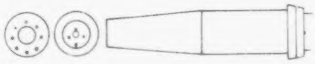
3.



2.



4.



(NOTE: Test item 12 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

12. Demonstrate the ability to

   a. Lay beads on light-gauge metal without filler rod.

   b. Lay beads on light-gauge metal with filler rod.

   c. Weld a butt joint with filler rod.

   d. Braze-weld a square-groove butt joint.

   e. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.

   f. Cut mild steel at a 90-degree angle, stop, and restart the cut.

OXYACETYLENE WELDING, BRAZING, AND CUTTING
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 2
   c. 6
   d. 9
   e. 8
   f. 4
   g. 7
   h. 1
   i. 5

2. a. Green
   b. Red

3. a. Oxidizing flame
   b. Carburizing flame
   c. Neutral flame

4. a. B
   b. F

5. a. 7
   b. 3
   c. 6
   d. 1
   e. 4
   f. 2
   g. 5

6. b, d, e, f, g

7. a. Thickness of base metal
   b. Properties of base metal

8. Answer should include any five of the following

   a. Chemically cleans base metal
   b. Prevents oxidation of filler metal
   c. Floats and removes oxides already present
   d. Increases flow of filler metal
   e. Increases ability of filler metal to adhere to base metal
   f. Brings filler metal into immediate contact with metals being joined
   g. Permits filler metal to penetrate pores of base metal

ANSWERS TO TEST

9. Answer should include any four of the following

   a. Provides increased strength
   b. Increases ductility
   c. Deoxidizes weld metal
   d. Decreases fuming
   e. Increases free-flowing action of molten metal
   f. Increases hardness of deposited metal

10. a. 6
    b. 11
    c. 1
    d. 8
    e. 7
    f. 10
    g. 2
    h. 9
    i. 4
    j. 3
    k. 5

11. a. 3
    b. 2
    c. 1
    d. 4

12. Performance skills evaluated to the satisfaction of the instructor

MIG WELDING AND PLASMA CUTTING
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to perform basic MIG welding and plasma cutting procedures commonly used in the auto-body shop. The student will show this ability by completing the assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with MIG welding and plasma cutting.
2. Label elements of the MIG welding process.
3. Select from a list characteristics of short-circuit transfer.
4. State normal electrode stickout (ESO) for short-circuit transfer.
5. State the effect of increasing electrode stickout.
6. Match typical MIG welder controls to their correct functions.
7. Label the parts of a MIG welding gun.
8. Match MIG gun tip parts to their correct uses.
9. Explain the meaning of each element in the electrode wire classification code.
10. State guidelines for handling and storing electrode wire spools.
11. Select from a list safety guidelines for working with electrode wire.
12. State characteristics of basic MIG welding techniques.
13. Label the parts of a plasma cutting-torch assembly.
14. Match common plasma cutting problems to their probable causes.
15. Determine correct duty-cycle requirements.

OBJECTIVE SHEET

16. Demonstrate the ability to

    a. Set up a spool-type wire feeder for MIG welding.

    b. Set up a flowmeter regulator for MIG shielding gases.

    c. Use short-circuit transfer to lay stringer beads on mild steel in the flat position.

    d. Use short-circuit transfer to construct a fillet weld lap joint on mild steel in the flat position.

    e. Use short-circuit transfer to construct a fillet weld T-joint on mild steel in the horizontal position.

    f. Use short-circuit transfer to construct a V-groove butt joint on mild steel in the vertical position.

    g. Use plasma cutting outfit to cut aluminum.

MIG WELDING AND PLASMA CUTTING
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

  A. Objective sheet

  B. Suggested activities

  C. Supplements

    1. Supplement #1 — Functions of Types of Gases Used in MIG Welding

    2. Supplement #2 — Points to Remember When MIG Welding

    3. Supplement #3 — Lens-Shade Selector Chart

    4. Supplement #4 — Points to Remember When Plasma Cutting

  D. Transparency masters

    1. TM #1 — MIG Equipment

    2. TM #2 — MIG Process

    3. TM #3 — MIG Electric Wire Stickout

    4. TM #4 — Arc Length and Arc Volt-Amp Characteristics

    5. TM #5 — Types of Gun Tip Components

    6. TM #6 — Shielding Gases and Welding Positions

    7. TM #7 — Parts of a Plasma Cutting Outfit

    8. TM #8 — Parts of a Plasma Cutting-Torch Assembly

  E. Information sheet

  F. Assignment sheets

    1. Assignment Sheet #1 — Determine Correct Duty-Cycle Requirements

    2. Assignment Sheet #2 -- List Probable Causes for Given Plasma Cutting Problems

  G. Answers to assignment sheets

SUGGESTED ACTIVITIES

H. Job sheets

1. Job Sheet #1 — Set Up a Spool-Type Wire Feeder for MIG Welding
2. Job Sheet #2 — Set Up a Flowmeter Regulator for MIG Shielding Gases
3. Job Sheet #3 — Use Short-Circuit Transfer to Lay Stringer Beads on Mild Steel in the Flat Position
4. Job Sheet #4 — Use Short-Circuit Transfer to Construct a Fillet Weld Lap Joint on Mild Steel in the Flat Position
5. Job Sheet #5 — Use Short-Circuit Transfer to Construct a Fillet Weld T-Joint on Mild Steel in the Horizontal Position
6. Job Sheet #6 — Use Short-Circuit Transfer to Construct a V-Groove Butt Joint on Mild Steel in the Vertical Position
7. Job Sheet #7 — Use Plasma Cutting Outfit to Cut Aluminum

I. Test

J. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Order or obtain equipment and materials needed to teach unit.

1. Equipment and materials needed for job sheet performance
2. Examples of various electrode wire sizes and types
3. Examples of various welding machines, MIG guns, and gun nozzles
4. Examples of plasma cutting outfits and pencilhead and 75-degree head
5. Welding and cutting charts from local welding supplier for classroom and shop display
6. Examples of good MIG welds and plasma cuts
7. Transparencies and competency profiles

(NOTE: Transparencies and competency profiles for this book are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

SUGGESTED ACTIVITIES

8. Audiovisual program, *MIG Welding*

   (NOTE: Titles in the program include "Gas Metal Arc Welding Process," "Wire Feeders and Torches," "Short-Circuit Transfer," "Spray-Arc Transfer," and "Troubleshooting." This program is available in sound filmstrips, sound slides, or videocassettes from Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss specific auto-body applications for MIG welding and plasma cutting.
- Discuss unit and specific objectives, pointing out that the specific objectives provide information necessary for accomplishment of the unit objective.

E. Discuss information, assignment, and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with MIG welding and plasma cutting.

   SUGGESTION:

   - Discuss each term, illustrating your discussion with examples when possible.

2. Use Information Sheet, Section II to introduce students to the elements of the MIG welding process.

   SUGGESTIONS:

   - Use Transparencies #1 and #2 to illustrate your discussion.
   - Show audiovisual "Gas Metal Arc Welding Process" from *MIG Welding* program.
   - Take students to the shop and demonstrate the process.
   - Have students complete Assignment Sheet #1. Discuss in class.

3. Use Information Sheet, Section III to discuss the characteristics of short-circuit transfer.

   SUGGESTION:

   - Show audiovisual "Short-Circuit Transfer" from *MIG Welding* program.

SUGGESTED ACTIVITIES

4. Use Information Sheet, Sections IV and V to discuss electrode stickout.

   SUGGESTION:

   - Use Transparencies #3 and #4 to illustrate your discussion.

5. Use Information Sheet, Section VI to discuss the functions of MIG welder controls.

   SUGGESTIONS:

   - Use an actual welder to point out and explain the functions of the controls.
   - Quiz the students on the functions of the controls by pointing to the controls and asking the students to write down the functions.

6. Use Information Sheet, Sections VII and VIII to introduce students to a MIG gun and gun tip parts.

   SUGGESTIONS:

   - Use Transparency #5 to illustrate your discussion.
   - Show students an actual MIG gun. Allow students to hold and examine the gun.
   - Assemble the components of the gun tip while explaining the functions of each component.
   - Show students different types of gun tips and explain the differences among them and the different uses of each in the auto-body shop.

7. Use Information Sheet, Section IX to discuss the meanings of the classification codes for electrode wires.

   SUGGESTION:

   - Have students practice decoding the following classifications: ER-70S-2, ER-70S-3, ER-70S-7, ER-80S-D2. Add other classifications particular to the auto-body trade as desired.

8. Use Information Sheet, Sections X and XI to discuss guidelines for working with electrode wire.

   SUGGESTIONS:

   - Stress safety precautions and the need for eye protection.
   - Show audiovisual "Wire Feeders and Torches" from *MIG Welding* program.
   - Demonstrate and discuss Job Sheet #1, and then have students complete this job sheet under your supervision.

SUGGESTED ACTIVITIES

9. Use Information Sheet, Section XII to discuss characteristics of basic MIG welding techniques.

   SUGGESTIONS:

   - Provide students with Supplements #1 through #3 for future reference.
   - Use Transparency #6 to illustrate your discussion.
   - Show filmstrip "Troubleshooting" from *MIG Welding* program.
   - Demonstrate and discuss Job Sheets #2 through #6. Schedule these job sheets and assign completion dates. Allow students to practice job sheet skills until they are proficient.

10. Use Information Sheet, Section XIII to introduce students to a typical plasma cutting-torch assembly.

    SUGGESTIONS:

    - Use Transparencies #7 and #8 to illustrate your discussion.
    - Assemble the components of the cutting tip while explaining the functions of each component.
    - Set up the plasma cutting outfit while pointing out its various parts and commenting on safety features and guidelines. Stress the high-voltage hazards connected with the machine.

11. Use Information Sheet, Section XIV to explain probable causes for common plasma cutting problems.

    SUGGESTIONS:

    - Provide each student with a copy of Supplement #4 for future reference.
    - Have students test themselves on this section by completing Assignment Sheet #2.
    - Discuss and demonstrate Job Sheet #7. Have the students complete this job sheet under your supervision. Allow students to practice the job sheet skills on other types of metal and until they are proficient in using the plasma cutting outfit.

F. Give test.

G. Critique test and discuss in class.

H. Complete appropriate section of competency profiles.

SUGGESTED ACTIVITIES

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

B. Fortney, Clarence, and Mike Gregory. *GMAW and FCAW Gas Metal Arc Welding and Flux-Cored Arc Welding*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1984.

C. Hendrix, Laborn J., "Bud." *Heavy Equipment Mechanic*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1985.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

E. *Owner's Manual No. OM-446: Model HSC-30A Plasma Cutting Package*. Troy, Ohio: Hobart Brothers Company, 1984.

F. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

SUGGESTED ACTIVITIES

SUPPLEMENT #1 — FUNCTIONS OF TYPES OF GASES USED IN MIG WELDING

Argon, $C0_2$, and oxygen are the three basic MIG shielding gases, and they are frequently used in combinations to accomplish specific MIG applications.

Argon is the most frequently used shielding gas because it produces a clean, narrow bead with deep penetration on nonferrous metals in both spray-arc and short-circuit transfer.

$C0_2$ is used primarily because it is far less expensive than other shielding gases, but it can cause an unstable arc and produce spatter if not used carefully, and it requires electrode wires with deoxidizing agents.

Oxygen is used in varying percentage combinations with argon for both spray-arc and short-circuit transfer on both mild steel and stainless steel.

Helium is used for some aluminum spray-arc applications and is mixed with argon for other aluminum applications in both short-circuit and spray-arc transfer, but helium does not produce the stable arc produced by argon.

SUGGESTED ACTIVITIES

SUPPLEMENT #2 — POINTS TO REMEMBER WHEN MIG WELDING

The most common sources of bad welds in the MIG process are incorrect ESO, incorrect angle, incorrect gas flow, the use of a dirty nozzle, and incorrect electrical settings. Besides using care and paying attention to your work, you can avoid some of these problems by observing the following guidelines.

1. Keep contact tip and nozzle clean at all times
2. Keep all cables free of kinks and pinches
3. Remember that although MIG is one of the easiest welding processes, electrical settings must be finely tuned for the process to work
4. Select the largest size wire that can be used for a given application
5. Do not adjust electrical controls while welding, such adjustment will burn out the MIG gun panel
6. Change only one variable at a time when adjusting process

   EXAMPLES: Current, voltage, amperage, arc length
7. Do not weld more than 1 inch at a time
8. Keep arc in leading edge of puddle

SUGGESTED ACTIVITIES

SUPPLEMENT #3 — LENS-SHADE SELECTOR CHART

Type of operation	Shade number
Soldering	2
Torch brazing	3 or 4
Oxygen cutting	
Base-metal thickness	
0 to 1 inch	3 or 4
1 to 6 inches	4 or 5
6 inches and over	5 or 6
Gas welding	
Base-metal thickness	
0 to 1/8 inch	4 or 5
1/8 to 1/2 inch	5 or 6
1/2 inch and over	6 or 8
Shielded metal-arc welding 1/16-, 3/4-, 1/8-, 5/32-inch electrodes	9 to 14
Gas-metal arc welding	9 to 14
Gas-tungsten arc welding (nonferrous), gas-metal arc welding (nonferrous) 1/16-, 3/32-, 1/8-, 5/32-inch electrodes	9 to 14
Gas-tungsten arc welding (ferrous), gas-metal arc welding (ferrous) 1/16-, 3/32-, 1/8-, 5/32-inch electrodes	9 to 14

(NOTE: In oxyacetylene welding and cutting, lens-shade requirements are based on metal thickness, but in gas-shielded arc welding, lens-shade requirements are based on electrode size, the amperage range of the electrode, and base-metal properties.)

SUGGESTED ACTIVITIES

SUPPLEMENT #4 — POINTS TO REMEMBER WHEN PLASMA CUTTING

1. Touch tip of torch to workpiece—or bring to within 0.20 inch of workpiece—holding torch at about a 15- to 30-degree angle to avoid damaging tip

2. After starting the cut, drag tip along workpiece, holding torch at about a 15- to 30-degree angle (like drawing a line with a pencil)

3. Keep tip-to-work distance at about 1/16 inch (particularly when cutting thick materials) to obtain the best quality cut and to preserve tip life

4. When ending cut, release torch switch and lift tip off workpiece *just before* end of cut to prevent double-arcing, which can damage tip

   (NOTE: This method of ending the cut prevents high frequency from reigniting after cutting arc extinguishes.)

5. Use cutting speed within range recommended for type and thickness of material being cut (Table 1)

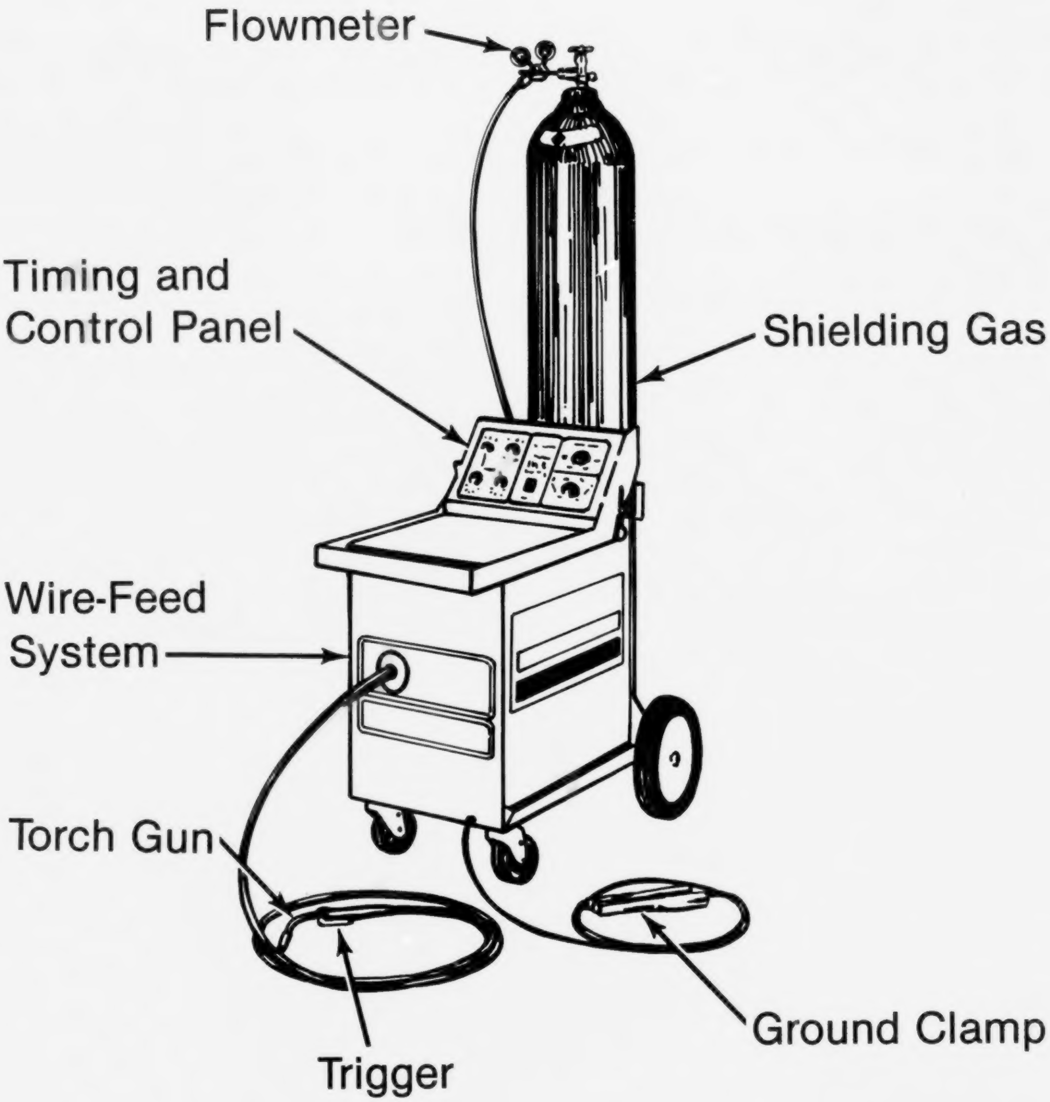
TABLE 1 Cutting Speed Range Using Air at 50 psi

Material	Thickness (In.)	Speed Range for Best Quality Cut* [ipm]
Carbon steel (AISI 1020)	5/16	8 to 10
	1/4	10 to 15
	1/8	40 to 60
	1/16	100 to 140
Stainless steel (AISI 304)	5/16	8 to 10
	1/4	10 to 15
	1/8	50 to 70
	1/16	100 to 140
Aluminum (AISI 6061)	5/16	8 to 10
	1/4	10 to 15
	1/8	50 to 70
	1/16	100 to 140

*Cutting speed on some materials can be substantially reduced with only slight reduction in cut quality (such as cutting 1/16-inch aluminum at 60 ipm) and still produce an acceptable cut.

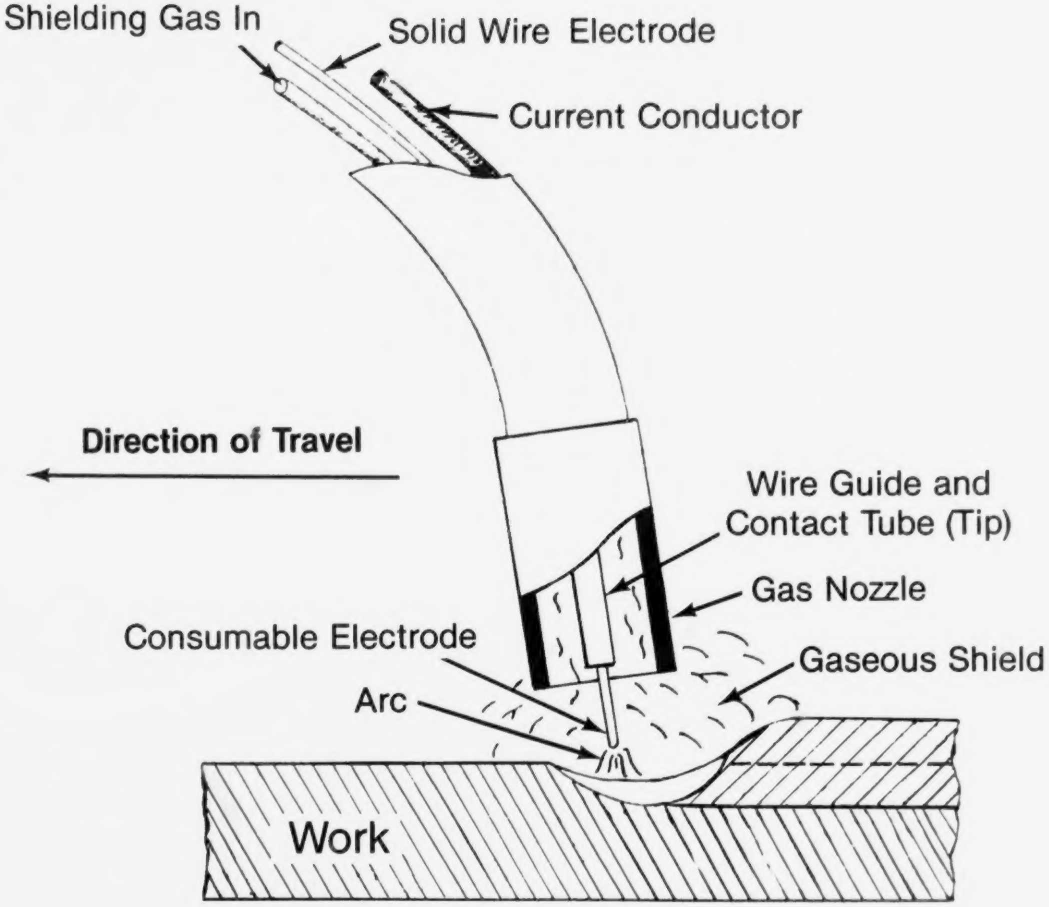
Used with permission of Hobart Brothers Company, Troy, Ohio.

MIG Equipment

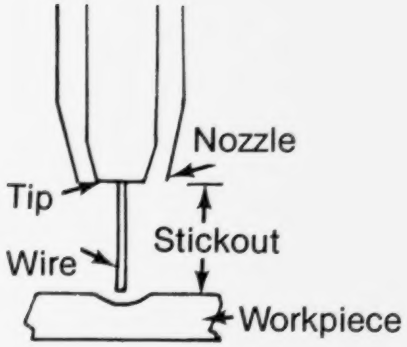


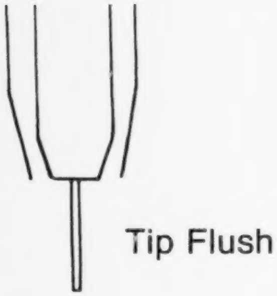
From *Owner's Manual No. OM-446 : Model HSC-30 A Plasma Cutting Package* by Hobart Brothers Company.

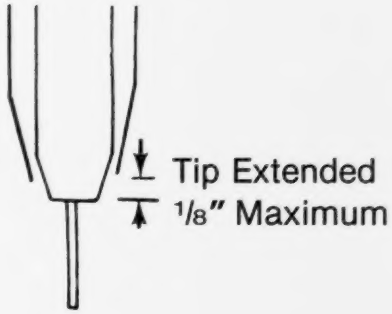
MIG Process

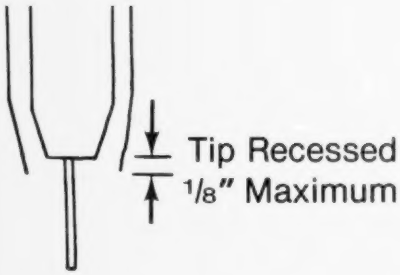

Shielding Gas In
Solid Wire Electrode
Current Conductor
Direction of Travel
Wire Guide and Contact Tube (Tip)
Gas Nozzle
Consumable Electrode
Gaseous Shield
Arc
Work

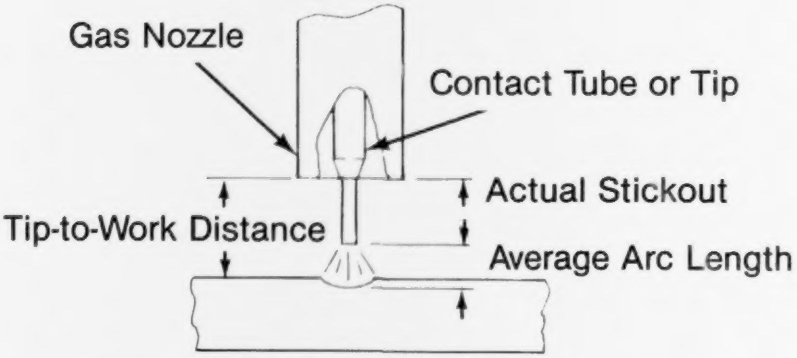
MIG Electric Wire Stickout







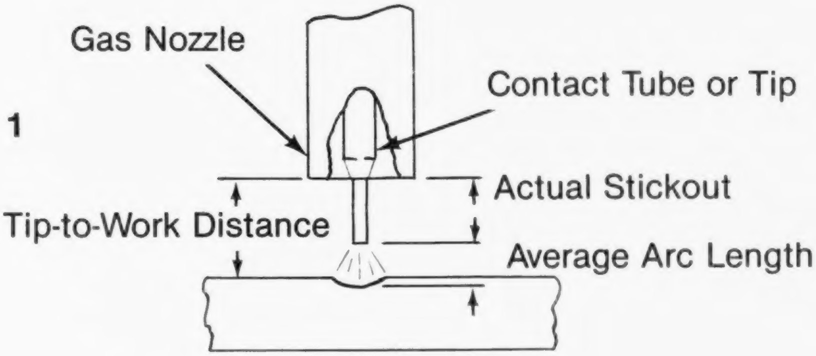




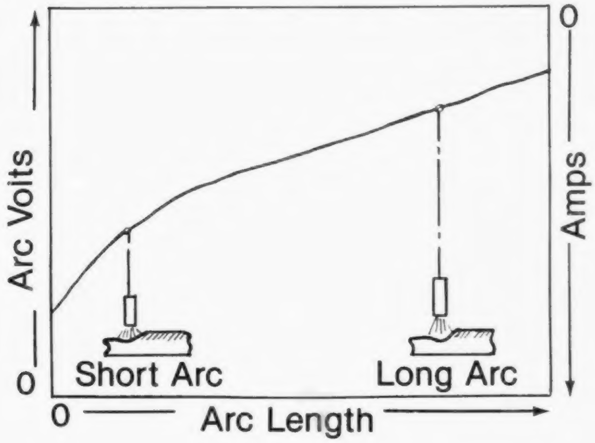
(Stickout Is Tip-to-Work)

Arc Length and Arc Volt-Amp Characteristics

1



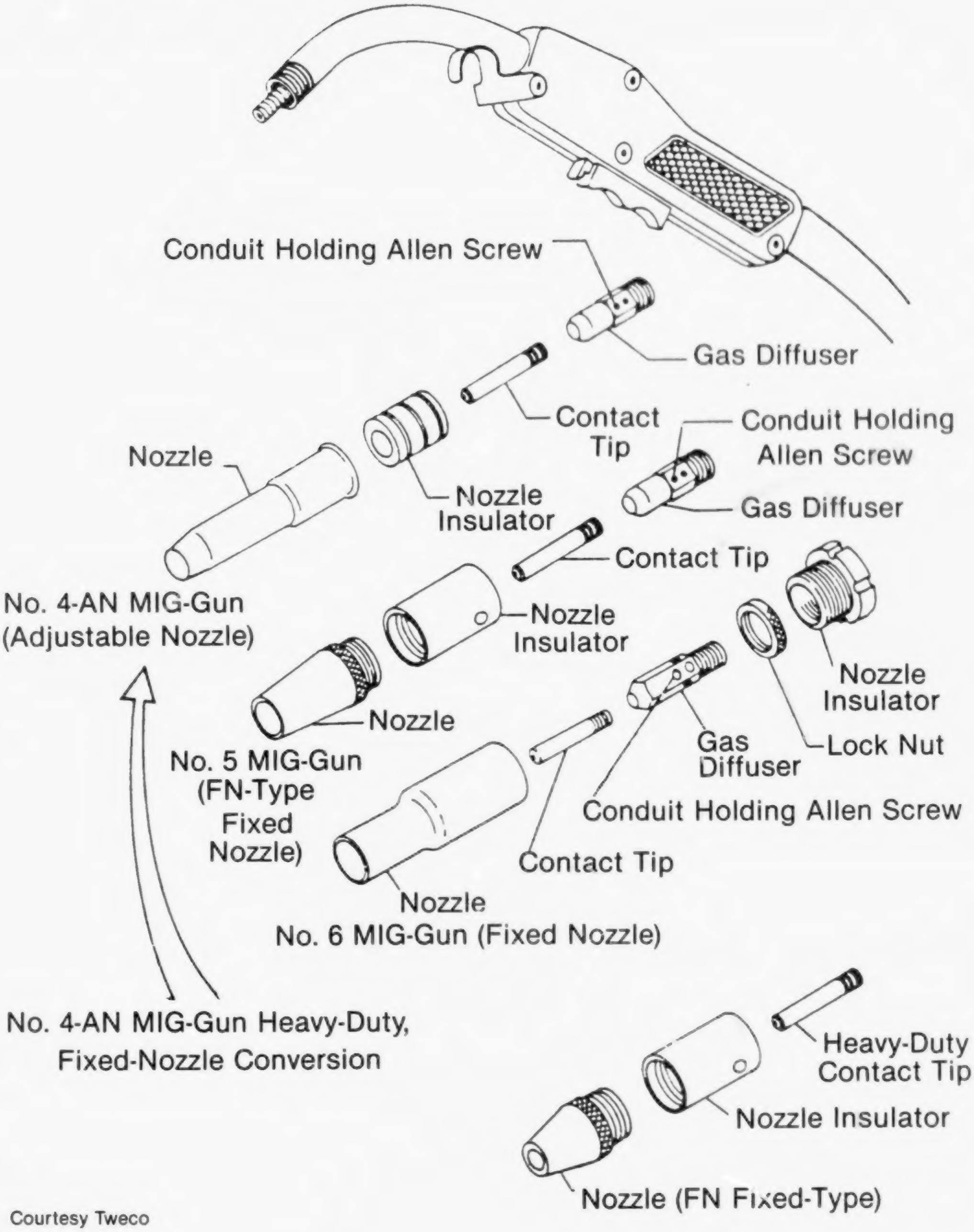
2



1. Small change in arc volts results in large change of welding current (amps).

2. Short arc length increases amps, decreases arc volts; long arc length increases arc volts, decreases amps.

Types of Gun Tip Components


Conduit Holding Allen Screw
Gas Diffuser
Contact Tip
Conduit Holding Allen Screw
Nozzle
Nozzle Insulator
Gas Diffuser
Contact Tip
No. 4-AN MIG-Gun (Adjustable Nozzle)
Nozzle Insulator
Nozzle Insulator
Nozzle
Gas Diffuser
Lock Nut
No. 5 MIG-Gun (FN-Type Fixed Nozzle)
Conduit Holding Allen Screw
Contact Tip
Nozzle
No. 6 MIG-Gun (Fixed Nozzle)
No. 4-AN MIG-Gun Heavy-Duty, Fixed-Nozzle Conversion
Heavy-Duty Contact Tip
Nozzle Insulator
Nozzle (FN Fixed-Type)

Courtesy Tweco

Shielding Gases and Welding Positions

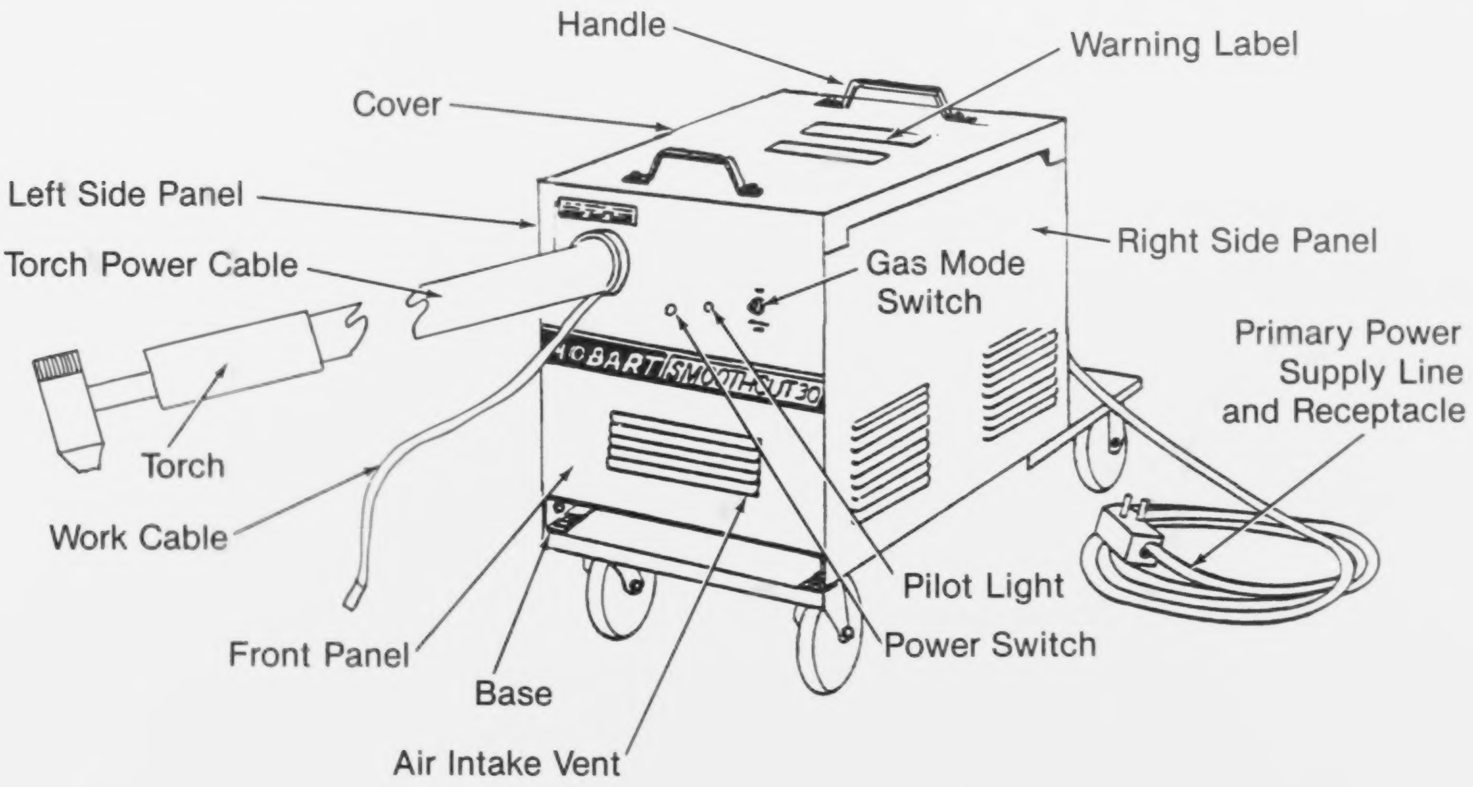
Gas	Spray-Arc Steel	Short-Circuit Steel	Spray-Arc Stainless Steel	Short-Circuit Stainless Steel	Spray-Arc Aluminum	Short-Circuit Aluminum
Argon					All positions	All positions
Argon + 1% 0_2	Flat and horizontal		Flat, horizontal, and overhead			
Argon + 2% 0_2	Flat and horizontal		Flat, horizontal, and overhead			
Argon + 5% 0_2	Flat and horizontal		Flat, horizontal, and overhead			
Argon + 25% $C0_2$		All positions		All positions*		
Argon + 50% $C0_2$		All positions		All positions		
$C0_2$	Flat and horizontal	All positions				
Helium					All positions	
Argon & Helium					All positions	All positions
Trimix**				All positions		
Argon + 7% $C0_2$	Flat and horizontal					

*Single Pass Welding Only

**90% Helium + 7½ % Argon + 2½ % $C0_2$

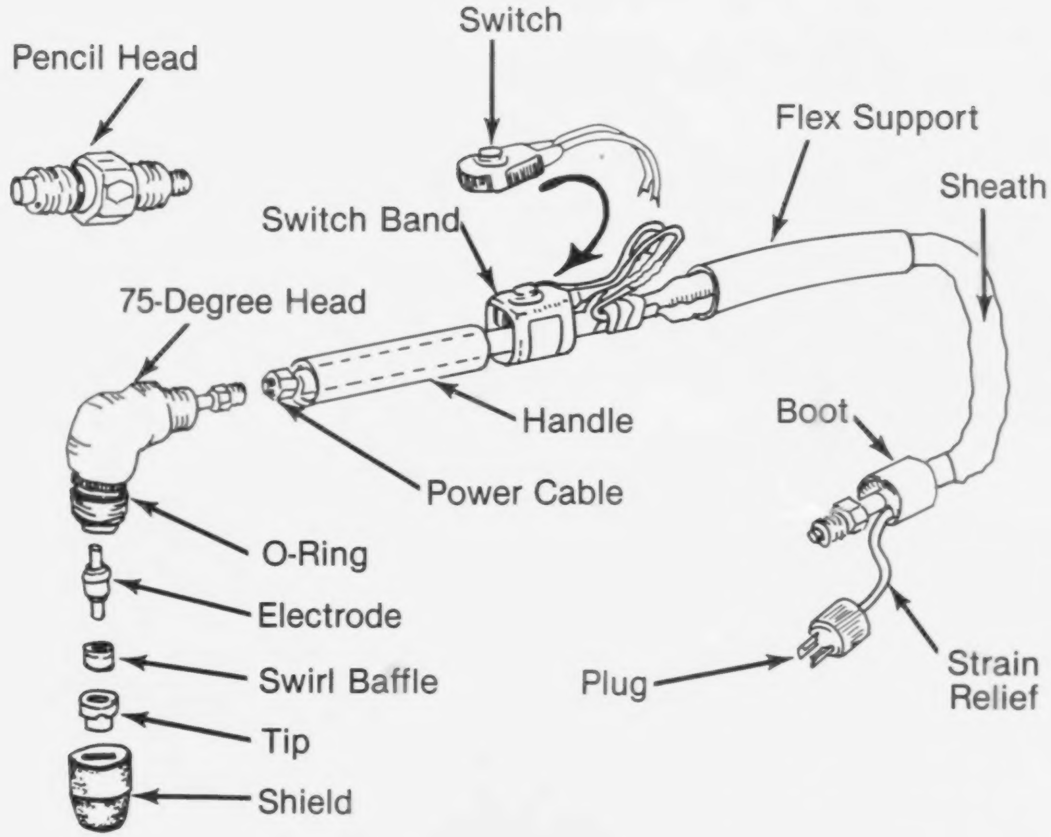
Courtesy Miller Electric Mfg. Co.

Parts of a Plasma Cutting Outfit



From *Owner's Manual No. OM-446 : Model HSC-30 A Plasma Cutting Package* by Hobart Brothers Company.

Parts of a Plasma Cutting-Torch Assembly



From *Owner's Manual No. OM-446 : Model HSC-30 A Plasma Cutting Package* by Hobart Brothers Company.

MIG WELDING AND PLASMA CUTTING
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Short-circuit transfer — MIG welding process that uses a short arc length, low voltage and current, and small-diameter wire

(NOTE: Short-circuit transfer is particularly well suited for welding thin metals in any position. Because of the low temperatures, short-circuit procedures are the preferred method of MIG welding in auto-body shops.)

B. Voltage — Basic measure of amount of electricity flowing past a point, as through a wire

(NOTE: Voltage is measured in volts by a device called a *voltmeter*. If compared to water flowing through a hose, voltage would be equivalent to the number of gallons of water passing through the hose. Most MIG welders have controls that allow the operator to adjust the number of volts flowing in the welding tip.)

C. Amperage (current) — Basic measure of strength of electricity flowing past a point, as through a wire

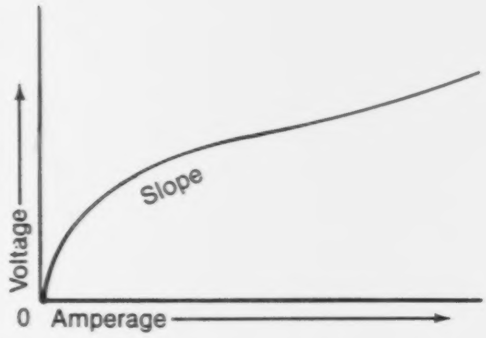
(NOTE: Amperage is measured in amperes by a device called an *ammeter*. If compared to water flowing through a hose, amperage can be thought of as the amount of pressure pushing the water through.)

D. Slope — Relationship between voltage and amperage in the operation of a MIG welder

(NOTE: The term *slope* comes from the line formed on a graph that compares voltage to amperage. See Figure 1. The voltage-amperage relationship is used in MIG welding to control welding processes such as penetration, rate of melt, bead width and size, etc. Some MIG welders have a slope control that allows the operator to adjust the voltage/amperage relationship.)

EXAMPLE:

FIGURE 1



INFORMATION SHEET

E. Inductance — Characteristic of a circuit that controls amount of voltage change possible

(NOTE: In MIG welding, inductance is adjusted to change the number of arcs per second to control the molten state of the weld material, making it more or less fluid.)

F. Resistance — Characteristic of a circuit that controls amount of amperage change possible

G. Duty cycle — Amount of time that an electrical device, such as a welder, may operate without suffering damage

H. Electrode stickout (ESO) — Distance that electrode extends beyond tip of welding gun

I. Spatter — Mixture of molten metal, melted electrode, and other fluid products of the welding process that splash out from weld

J. Insulate — Use of nonconducting materials to stop or reduce the flow of energy

K. Polarity — Direction of electrical flow

(NOTE: Electrical flow is either *straight polarity* [positive to negative] or *reverse polarity* [negative to positive]. MIG welding is generally done using reverse polarity.)

L. Inches per minute (ipm) — Measure of rate of feed for MIG electrode wire

M. Cubic feet per hour (cfh) — Measure of rate of flow of shielding gas in MIG welding

N. Plasma — High-temperature ionized gas

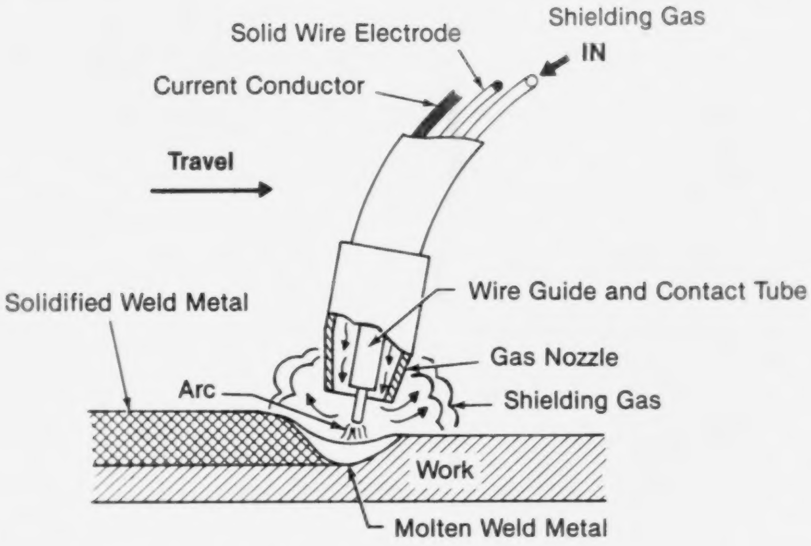
O. Dross — Scum formed on surface of molten metal

II. Elements of the MIG welding process (See Figure 2)

(NOTE: In MIG welding, a solid wire electrode is fed from a reel to the welding tip at a preset speed measured in inches per minute. The rate of feed controls the welding amperage, while voltage is adjusted by means of a dial on the welding machine. Shielding gas is forced around the electrode wire from a cylinder of compressed gas. The shielding gas helps to protect the weld from other gases in the air and keeps the weld clean.)

INFORMATION SHEET

FIGURE 2



Courtesy Lincoln Electric Company

III. Characteristics of short-circuit transfer

A. Is commmonly used for thin metals, such as body metal, and for high-strength, low-alloy steel

B. Uses relatively low voltages and current; operating voltages range from 15 volts to 22 volts, depending on wire size and shielding gas

C. Metal does not transfer across arc, but melts off when electrode wire makes contact with base metal

D. Is used primarily for wires less than 0.045 inch in diameter

E. Amperage is controlled by wire-feed speed

F. Frequently uses moderate slope adjustment to avoid spatter

G. Produces less heat in the base metal than spray-arc transfer method used for thicker metals

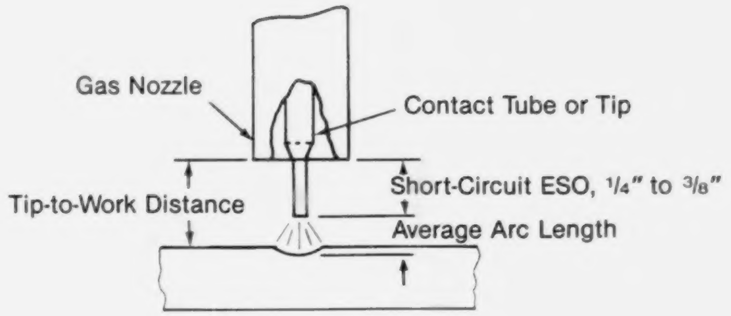
IV. Normal electrode stickout (ESO) for short-circuit transfer — 1/4 inch to 3/8 inch (See Figure 3)

(NOTE: The distance that the electrode extends beyond the end of the gas nozzle is used to adjust amperage and voltage, and thus influences penetration and bead width.)

INFORMATION SHEET

EXAMPLE:

FIGURE 3



V. Effect of increasing electrode stickout — Decreases amperage and increases voltage

VI. Functions of typical MIG welder controls

A. Machine control functions

1. Power supply — Controls current and voltage used in the basic MIG processes

2. Wire feeder — Varies and controls speed at which wire is fed to welding arc in relation to amperage and wire-feed speed

3. Cable assembly — Transports power to trigger-operated gun

4. Gun — Starts or stops flow of wire, shielding gas, and coolant to weld zone

5. Flowmeter regulator — Reduces high-pressure cylinder gas to low-pressure gas so its flow rate can be controlled to the welding gun as measured in cfh

B. Electrical control functions

1. On/off switch — Starts or stops electrical power to welder

2. Voltage range selector — Controls wide-range voltage selection, such as 12 volts to 28 volts for low range and 20 volts to 35 volts for high range

3. Fine voltage control — Fine tunes voltage selection within wide-range setting

4. Power supply voltmeter — Indicates voltage levels

5. Power supply ammeter — Indicates amperage levels

INFORMATION SHEET

6. Slope control — Increases or decreases rate of resistance change

7. Polarity switch — Changes polarity from reverse to straight so that meters for amperes and volts can be properly read

8. Contactor control — Completes circuit through wire feed and functions as an on/off device for wire feed

9. Inductance control — Controls arc-on time in short-circuit welding to control puddle fluidity and produce a flat, smooth weld bead

C. Wire-feeder control functions

1. On/off switch — Controls power input into wire-feed mechanism

2. Amp/ipm switch — Functions as a dual control to regulate wire-feed rate in inches per minute in relation to amperage

3. Contactor dropout control — Increases or decreases burn-back on ESO

   (NOTE: *Burn-back* is the length of electrode melting at the tip.)

4. Spot weld function switch — Routes current through a timer to provide a specific time for trigger activation, regardless of how long or how briefly the trigger is held

5. Purge control — Permits purging of a shielding gas through gun without having wire feed at the same time

6. Wire-inch switch — Advances wire for setup without activating other components

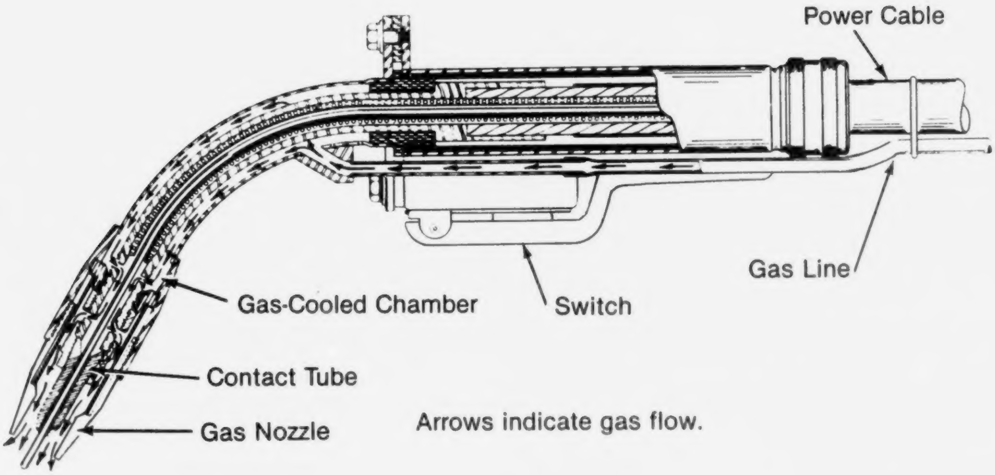
7. Wire-feed voltage and amperage control — Sets and adjusts voltage and amperage in the wire-feed mechanism

VII. Parts of a MIG welding gun (See Figure 4)

(NOTE: The air-cooled gun illustrated on the next page is the most commonly used MIG gun in the auto-body shop. Air-cooled guns are used primarily for short-distance welds or short-interval welds [such as spot welding or tacking] using short-circuit transfer.)

INFORMATION SHEET

FIGURE 4



Courtesy American Welding Society

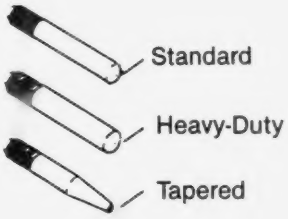
VIII. Uses of MIG gun tip parts

A. Contact tip — Copper device used to guide wire to weld; available in standard, heavy-duty, and tapered designs (Figure 5)

(NOTE: The contact tip should be selected according to wire size and type of service.)

EXAMPLE:

FIGURE 5



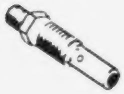
Courtesy Tweco.

INFORMATION SHEET

B. Gas diffuser — Copper device that spreads shielding gas out so that it flows evenly over electrode wire and weld zone (Figure 6)

EXAMPLE:

FIGURE 6

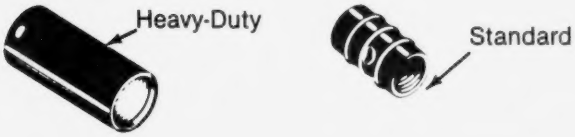


Courtesy Tweco.

C. Nozzle insulator — Device used to insulate nozzle from welding current and to hold nozzle in place (Figure 7)

EXAMPLE:

FIGURE 7

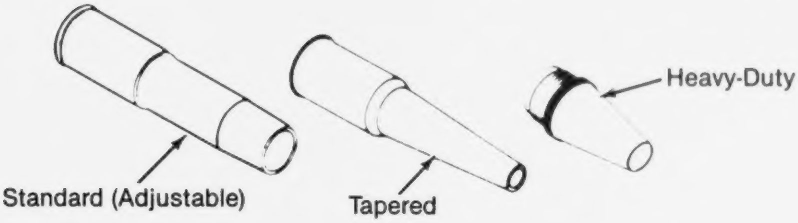


Courtesy Tweco.

D. Nozzle — Specially shaped device used to direct and hold shielding gas around weld zone; may be standard, tapered for tight places, or heavy-duty for continuous welding (Figure 8)

EXAMPLE:

FIGURE 8



Courtesy Tweco.

INFORMATION SHEET

IX. Classifications for electrode wires

(NOTE: American Welding Society [AWS] classifications for electrode wires use letter and number designations to identify the type of electrode and its basic composition.)

A. **E** — Indicates electrode

B. **R** — Indicates that the filler metal may be used as an electrode or welding rod

C. **Numbers** — Indicate minimum tensile strength in multiples of 1000 psi

D. **S** — Indicates a bare, solid electrode or rod

E. **T** — Indicates a flux-cored, tubed electrode

F. **Final letter/number** — Indicates special chemical compositions of electrode wire

EXAMPLE: With an ER-80S-B2 electrode wire, the **E** indicates an electrode, the **R** indicates the wire can be used as a welding rod, the **80** indicates a tensile strength of 80,000 psi, the **S** indicates a solid electrode, and the **B2** indicates that the electrode contains a certain amount of bismuth, an element with a low melting point to give the electrode that special characteristic.

X. Guidelines for handling and storing electrode wire spools

A. Do not unseal spools or coils until they are needed for immediate use

B. Store electrode wires in dry place

C. Use spools or coils as soon after opening as possible

D. Cover or reseal remaining wire prior to storage

XI. Safety guidelines for working with electrode wire

A. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye

B. Make sure that you have the correct spool or coil before loading and cutting tie wires

C. Hold free end of electrode wire firmly to avoid backlash during reloading procedure; failure to do so could ruin an entire spool or coil

D. Position coils close to reel before lifting, and lift with your legs, not your back

(NOTE: Standard coils weigh 50 to 60 pounds)

E. Never look into a gun while feeding wire through it

INFORMATION SHEET

F. Never point the gun at yourself or at anyone else

G. Never place a finger or hand over a contact tip to see whether or not wire is feeding properly

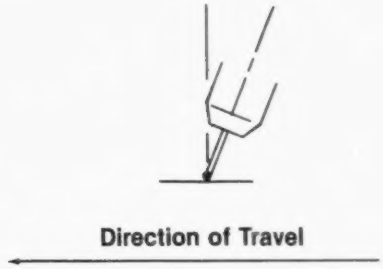
XII. Characteristics of basic MIG welding techniques

A. Push technique (forehand technique)

1. Electrode points in direction of travel (Figure 9)

EXAMPLE:

FIGURE 9

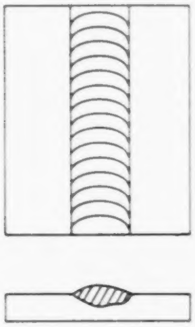


Courtesy American Welding Society.

2. Technique decreases penetration and gives a wide, flat bead (Figure 10)

EXAMPLE:

FIGURE 10



Courtesy American Welding Society.

3. Technique is used mostly on thick metals

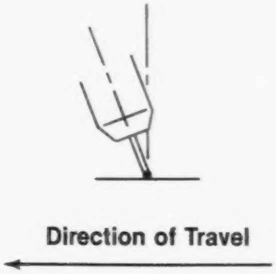
INFORMATION SHEET

B. Pull technique (backhand or drag technique)

1. Electrode points opposite direction of travel (Figure 11)

   EXAMPLE:

FIGURE 11

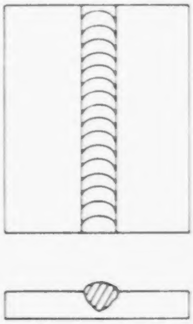


Courtesy American Welding Society.

2. Technique increases penetration; gives a convex, narrow bead; provides a more stable arc; and leaves less spatter on workpiece (Figure 12)

   EXAMPLE:

FIGURE 12



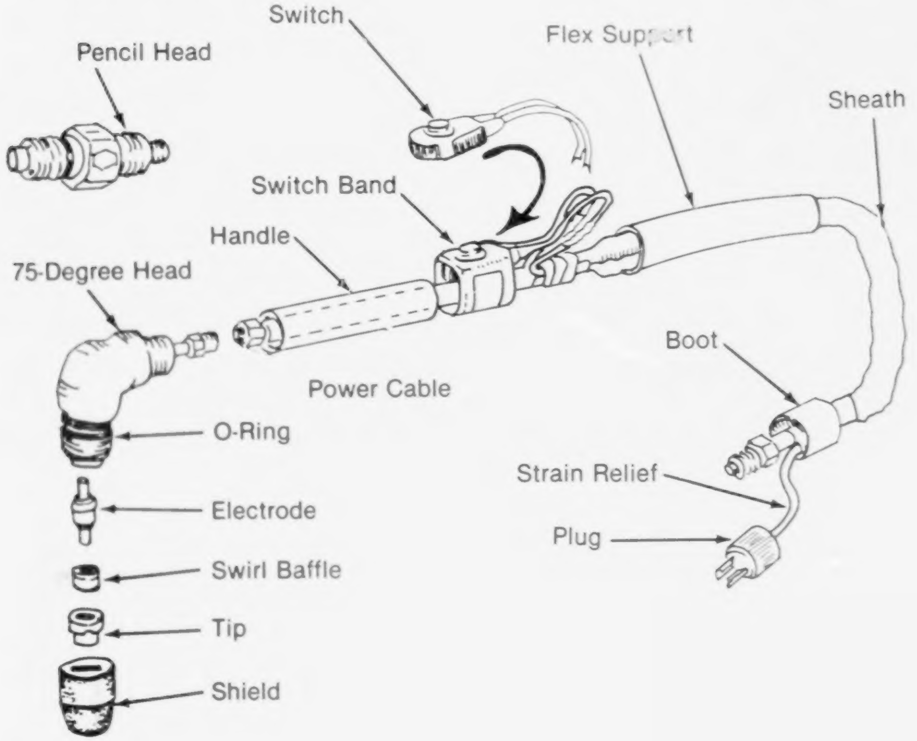
Courtesy American Welding Society.

3. Technique is used mostly on thin metals

INFORMATION SHEET

XIII. Parts of a plasma cutting-torch assembly (Figure 13)

FIGURE 13



XIV. Probable causes of common plasma cutting problems

A. Insufficient penetration

1. Cutting speed too fast
2. Damaged cutting tip
3. Improper gas pressure

B. Main arc extinguishes — Cutting speed too slow

C. Dross formation

(NOTE: In some materials and thicknesses, it may be impossible to get dross-free cuts.)

1. Cutting speed too fast or too slow
2. Improper gas pressure
3. Faulty tip or electrode

INFORMATION SHEET

D. Double arcing (damaged tip orifice)
    1. Gas pressure too low
    2. Damaged cutting tip
    3. Loose cutting tip
    4. Heavy spatter

E. Uneven arc
    1. Damaged cutting tip
    2. Electrode not straight or centered

F. Unstable cutting conditions
    1. Incorrect cutting speed
    2. Loose connections
    3. Electrode and/or cutting tip in poor condition

G. Main arc does not strike — Loose connections

H. Poor consumable life — Improper gas pressure

MIG WELDING AND PLASMA CUTTING
UNIT III

ASSIGNMENT SHEET #1 — DETERMINE CORRECT DUTY-CYCLE REQUIREMENTS

NAME ______________________________ SCORE ____________

Electric welding machines operate by producing heat through electrical resistance. Therefore, it is necessary to take precautions to avoid overheating the machine. For this reason, organizations such as the National Electrical Manufacturers Association (NEMA) rate welding machines to show how long they can operate safely at full power during a ten-minute period. This period is called a *duty cycle* and is given as a percentage. Thus, a machine with a 50 percent duty cycle could safely operate for five minutes of a ten-minute period. All MIG welders are marked with a NEMA classification that determines the duty cycle. The classes are as follows:

Class I—Rated to deliver output at duty cycles of 60, 80, or 100 percent;

Class II—Rated to deliver output at duty cycles of 30, 40, or 50 percent;

Class III—Rated to deliver output at a duty cycle of 20 percent.

The welding machine operator must follow these classification recommendations to avoid damaging or ruining expensive equipment and to lessen the chance of electrical dangers and accidental fires.

Read each of the following situations, and then answer the questions concerning the correct duty-cycle requirements on the blanks provided.

____________________ A. A technician is using a Class II welder. Can she use the machine for more than 5 minutes of continuous operation at full power?

____________________ B. A Class I welder is rated at 80 percent. How long can the machine be used at continuous maximum output in a 10-minute period?

____________________ C. A technician is using a Class III machine and runs the welder for 3 minutes within a 10-minute period? Is this within safe standards?

____________________ D. A technician begins welding at 1:10 P.M. and welds off and on until 1:25 P.M. During that time, he operates the welder at full power for periods of 2 minutes, 1 1/2 minutes, 1 minute, 1 1/2 minutes, and then uses it for 3 minutes before shutting it down. If the welder is Class I with a 60 percent rating, was the work done within limits?

____________________ E. For how many minutes of continuous, full-power operation can a technician use a Class II welder during a 10-minute period if the machine has a rating of 40 percent?

MIG WELDING AND PLASMA CUTTING
UNIT III

ASSIGNMENT SHEET #2 — LIST PROBABLE CAUSES FOR GIVEN PLASMA CUTTING PROBLEMS

NAME ________________________________ SCORE ______________

The technician should be able to determine the causes of any problems encountered in the use of plasma cutting equipment. This assignment sheet is designed to give you practice in remembering causes for common cutting problems. List below probable causes for the given plasma cutting problems.

A. Insufficient penetration

1. ____
2. ____
3. ____

B. Main arc extinguishes — ______________________________

C. Dross formation

1. ____
2. ____
3. ____

D. Double arcing (damaged tip orifice)

1. ____
2. ____
3. ____
4. ____

E. Uneven arc

1. ____
2. ____

F. Unstable cutting conditions

1. ____
2. ____
3. ____

ASSIGNMENT SHEET #2

G. Main arc does not strike — ____

H. Poor consumable life — ____

MIG WELDING AND PLASMA CUTTING
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. No
B. 8 minutes
C. No
D. Yes
E. 4 minutes

Assignment Sheet #2

A. Insufficient penetration
    1. Cutting speed too fast
    2. Damaged cutting tip
    3. Improper gas pressure
B. Main arc extinguishes — Cutting speed too slow
C. Dross formation
    1. Cutting speed too fast or too slow
    2. Improper gas pressure
    3. Faulty tip or electrode
D. Double arcing (damaged tip orifice)
    1. Gas pressure too low
    2. Damaged cutting tip
    3. Loose cutting tip
    4. Heavy spatter
E. Uneven arc
    1. Damaged cutting tip
    2. Electrode not straight or centered
F. Unstable cutting conditions
    1. Incorrect cutting speed
    2. Loose connections
    3. Electrode and/or cutting tip in poor condition
G. Main arc does not strike — Loose connections
H. Poor consumable life — Improper gas pressure

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #1 — SET UP A SPOOL-TYPE WIRE FEEDER FOR MIG WELDING

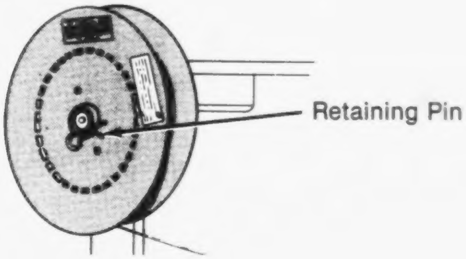
I. Equipment and materials

- A. MIG welder and accessories
- B. Eye protection
- C. Electrode wire, spool or coil
- D. Screwdriver
- E. Adjustable wrench
- F. Wire-cutting pliers
- G. Fine-cut file
- H. Nozzle spray or gel

II. Procedure

- A. Put on eye protection
- B. Shut off input power to power supply and wire feeder
- C. Remove nozzle from MIG gun
- D. Cut tip of wire off at ESO if replacing wire
- E. Use pliers to slide contact tip out over wire, being careful not to remove the gas diffuser
- F. Release feed-roll spring tension
- G. If replacing wire, pull remaining wire through cable and gun, and dispose of it
- H. Remove retaining collar that holds spool in place by loosening thumbscrew or removing retaining pin that secures it (Figure 14)

FIGURE 14



JOB SHEET #1

I. Remove empty spool from spindle

J. Locate end of wire on new spool; position new spool so that wire will feed from bottom of spool into wire feeder

> **CAUTION**
>
> Do not remove the free end of the wire from the retaining hole where it is secured or the wire will uncoil.

K. Place new spool or wire onto spindle, making sure that drag brake pin slips into proper hole

L. Replace retaining collar by forcing it tightly against reel and tightening thumbscrew or replacing retaining pin that secures it

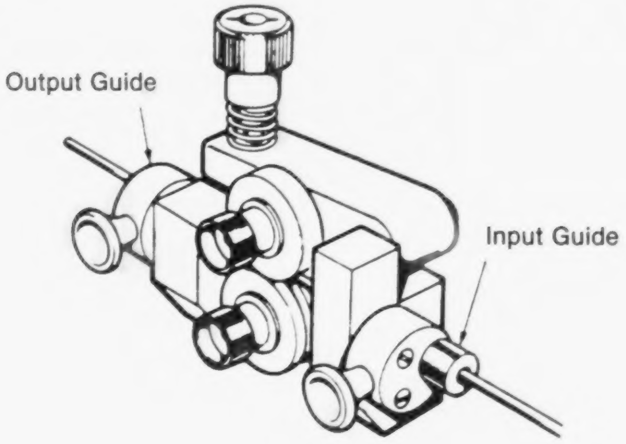
M. Locate end of wire on spool, free it from retaining hole, and clip the end of it

(NOTE: Hang on to the free end of the wire firmly throughout this procedure.)

N. File smooth the sharp, cut end of the wire so that wire will not puncture inside of cable conduit

O. Guide clean, free end of wire through insulated input guide, using both hands to push and pull wires across top of bottom feed roller and through insulated output guide (Figure 15)

FIGURE 15



Courtesy John Wiley and Sons, Inc.

JOB SHEET #1

P. Continue pushing and pulling the wire until it moves into and through the wire-feed power assembly 2 to 3 inches

(NOTE: Do not force the wire into the wire-feed assembly, just work it back and forth until it fits smoothly.)

Q. Bring top feed roll down so that wire lies in groove between both rollers

R. Use a screwdriver, or thumbscrew, to tighten pressure-adjusting screw to provide operating pressure between bottom and top rollers

CAUTION

Do not overtighten the adjusting screw and cause the wire to flatten out.

S. Turn on power supply and wire-feed power

T. Position gun so that cable conduit between wire feeder and gun is straight

(NOTE: Use the wire-inch control for the following adjustment because it will help keep from shorting out the gas diffuser and wasting expensive shielding gas. If the machine does not have a wire-inch control, perform the procedure manually, exercising care to avoid excess gas leakage.)

U. Turn wire-inch on, or manually feed wire through cable conduit to gun

V. As you feed the wire, test tension by pinching the wire just ahead of insulated input guide

(NOTE: If a slight pinching pressure will stop the wire from feeding through, the tension is probably all right. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.)

W. Turn off power supply and wire-feed supply

X. Replace contact tip required for size wire you are using, and then tighten contact tip with pliers

Y. Replace nozzle over contact tip

Z. Adjust machine for specified welding activity

AA. Clean work area and return equipment and materials to proper storage, or continue with welding procedures

(NOTE: The procedure for replacing a coil-type wire reel is essentially the same as that for a spool-type reel, except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves for replacement coil installation.)

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #2 — SET UP A FLOWMETER REGULATOR FOR MIG SHIELDING GASES

I. Equipment materials

A. MIG welder and accessories

B. Argon or helium cylinder

C. Flowmeter regulator

D. Adjustable wrench or 1 1/8-inch open-end wrench

E. Eye protection

II. Procedure

A. Put on eye protection

B. Check to see that gas cylinder is safely secured in an upright position

C. Remove cylinder cap

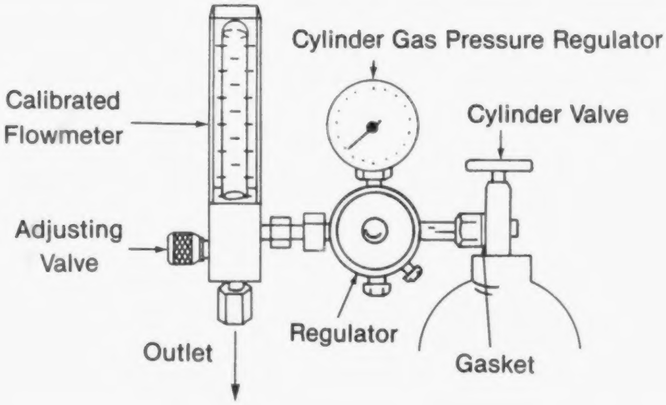
D. Crack cylinder valve slightly to clear cylinder valve fitting

E. Check gasket and attach flowmeter regulator to cylinder valve

F. Tighten regulator fitting nut with wrench, but do not overtighten

G. Check to make sure that flowmeter adjusting valve is shut off by turning it clockwise until it is tight (Figure 16)

FIGURE 16



JOB SHEET #2

H. Open gas cylinder valve all the way so that it will backseat against top of valve

I. Set up and turn on MIG welder

J. Turn flowmeter adjusting screw counterclockwise until ball starts to rise in flowmeter

(NOTE: If ball is not rising, check to see if wire feed is turned on.)

K. Move adjusting screw clockwise or counterclockwise to make adjustment to cfh recommended by instructor

(NOTE: The very top of the ball is the reference point for measuring cfh.)

L. Clean work area and return equipment and materials to proper storage, or continue with welding procedures

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #3 — USE SHORT-CIRCUIT TRANSFER TO LAY STRINGER BEADS ON MILD STEEL IN THE FLAT POSITION

I. Equipment and materials

  A. MIG welder with accessories

  B. Protective clothing and equipment

  C. Eye protection

  D. Wire and shielding gas

  E. Mild steel

  F. Wire-cutting pliers

  G. Wire brush

  H. Flowmeter regulator

  I. Adjustable wrench or 1 $^{1}/_{8}$-inch open-end wrench

  J. C-clamps or bench vise

II. Procedure

  A. Put on eye protection and protective clothing

  B. Inspect work area to see that it is free of combustible materials; determine location of nearest fire extinguisher

> **CAUTION**
>
> If working on an actual vehicle, disconnect battery and remove computer if vehicle is so equipped. Refer to vehicle service manual.

  C. Attach flowmeter regulator to shielding gas and adjust flow rate as outlined in Job Sheet #2

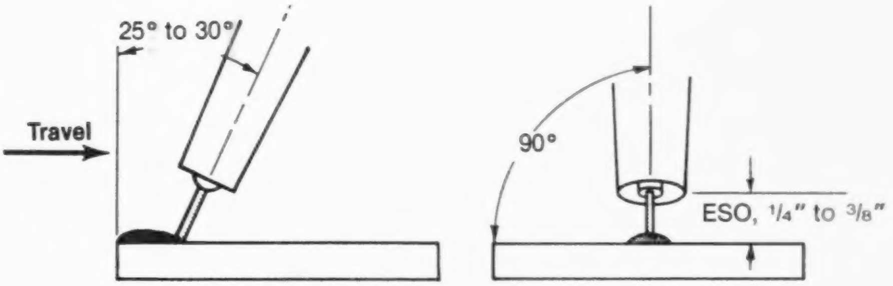
  D. Complete equipment setup for short-circuit transfer

  E. Adjust controls for metal thickness and wire diameter

  F. Position work to be welded and secure in position

G. Move gun down to plate; check gun angle and ESO as shown in Figure 17

FIGURE 17



Side View

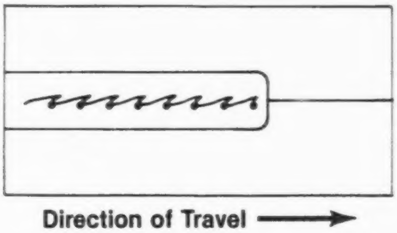
End View

H. Squeeze gun trigger and use push or pull technique to lay bead from left to right if right-handed, and right to left if left-handed

(NOTE: The cups for guns are large enough that they block the view of the weld zone unless you position yourself properly and lay the bead in the correct direction to maintain correct gun angle and ESO.)

I. Weld bead to desired length, using motion shown in Figure 18

FIGURE 18



J. Crater and fill to complete the bead

1. Release gun trigger just as bead reaches end of weld
2. Hold gun in place and hesitate slightly to keep molten puddle covered with shielding gas
3. Pull gun away

   (NOTE: Holding the gun in position after releasing the trigger allows the wire to continue melting long enough to fill the crater.)

JOB SHEET #3

K. Put gun in safe place

L. Clean weld with wire brush as required

M. Inspect weld for good penetration and fusion, uniform bead width and appearance, and defects such as excessive spatter and undercutting

N. Shut down equipment once good weld is achieved

O. Clean work area and return equipment and materials to proper storage

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #4 — USE SHORT-CIRCUIT TRANSFER TO CONSTRUCT A FILLET WELD LAP JOINT ON MILD STEEL IN THE FLAT POSITION

I. Equipment and materials

- A. MIG welder with accessories
- B. Protective clothing and equipment
- C. Eye protection
- D. Wire and shielding gas
- E. Mild steel
- F. Wire-cutting pliers
- G. Bench vise
- H. Hammer
- I. Wire brush
- J. Flowmeter regulator
- K. Adjustable wrench or 1 $^1/_8$-inch open-end wrench

II. Procedure

- A. Put on eye protection and protective clothing
- B. Inspect work area to see that it is free of combustible materials; determine location of nearest fire extinguisher

> **CAUTION**
>
> If working on an actual vehicle, disconnect battery and remove computer if vehicle is so equipped. Refer to vehicle service manual.

- C. Attach flowmeter regulator to shielding gas and adjust flow rate as outlined in Job Sheet #2
- D. Complete equipment setup for short-circuit transfer
- E. Adjust controls for metal thickness and wire diameter

JOB SHEET #4

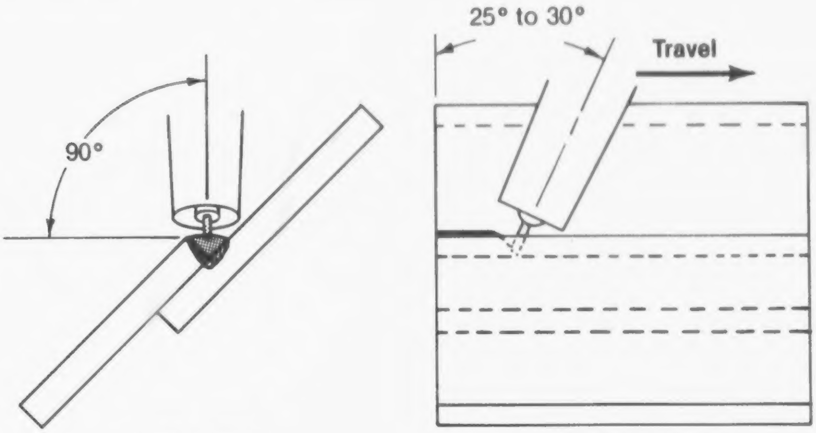
F. Make a test bead on scrap metal and make necessary adjustments

G. Position work in correct welding position and secure

H. Tack joint every 1 to 2 inches

I. Position gun at correct angle to joint and check ESO (Figure 19)

FIGURE 19



End View

Side View

J. Squeeze gun trigger and use push or pull technique to weld joint, being sure to position yourself so that you can see to maintain correct gun angle and ESO

K. Crater and fill to end the weld

L. Put gun in safe place

M. Clean joint with wire brush as required

N. Inspect joint visually

O. Shut down equipment once good weld is achieved

P. Clean work area and return equipment and materials to proper storage

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #5 — USE SHORT-CIRCUIT TRANSFER TO CONSTRUCT A FILLET WELD T-JOINT ON MILD STEEL IN THE HORIZONTAL POSITION

I. Equipment and materials

- A. MIG welder with accessories
- B. Protective clothing and equipment
- C. Eye protection
- D. Wire and shielding gas
- E. Mild steel
- F. Wire-cutting pliers
- G. Wire brush
- H. C-clamps or bench vise
- I. Flowmeter regulator
- J. Adjustable wrench or 1 1/8-inch open-end wrench

II. Procedure

- A. Put on eye protection and protective clothing
- B. Inspect work area to see that it is free of combustible materials; determine location of nearest fire extinguisher

> **CAUTION**
>
> If working on an actual vehicle, disconnect battery and remove computer if vehicle is so equipped. Refer to vehicle service manual.

- C. Attach flowmeter regulator to sheilding gas and adjust flow rate as outlined in Job Sheet #2
- D. Complete equipment setup for short-circuit transfer
- E. Adjust controls for metal thickness and wire diameter
- F. Make a test bead on scrap metal and make necessary adjustments

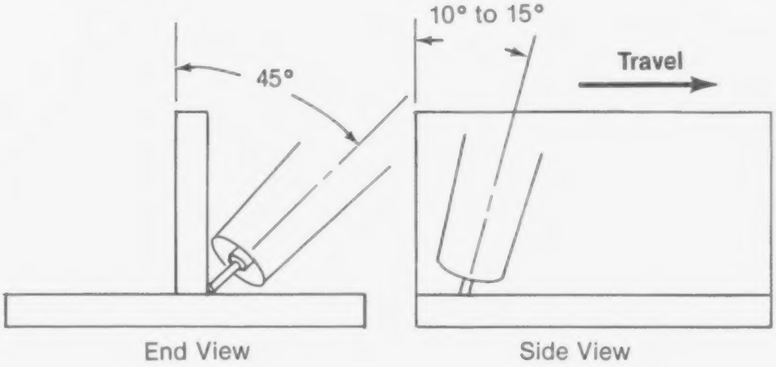
JOB SHEET #5

G. Position work in correct welding position and secure

H. Tack joint every 1 to 2 inches

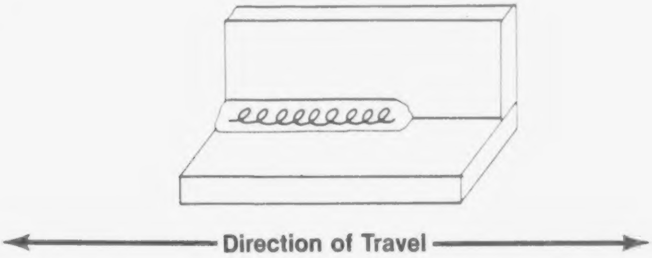
I. Position gun at correct angle to joint and check ESO (Figure 20)

FIGURE 20



J. Squeeze gun trigger and use motion shown in Figure 21, being sure to position yourself so that you can see to maintain correct gun angle and ESO

FIGURE 21



K. Weld for approximately 1 inch and then move to opposite end of joint and weld for approximately 1 inch

L. Continue alternating welding locations until weld in complete

(NOTE: Alternating welding sites and welding for short distances minimizes heat buildup, which weakens the metal.)

M. Put gun in safe place

JOB SHEET #5

N. Clean weld with wire brush as required

O. Inspect joint visually

P. Shut down equipment once weld is complete

Q. Clean work area and return equipment and materials to proper storage

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #6 — USE SHORT-CIRCUIT TRANSFER TO CONSTRUCT A V-GROOVE BUTT JOINT ON MILD STEEL IN THE VERTICAL POSITION

I. Equipment and materials

A. MIG welder with accessories

B. Protective clothing and equipment

C. Eye protection

D. Wire and shielding gas

E. Mild steel

F. Wire-cutting pliers

G. Wire brush

H. C-clamps or bench vise

I. Flowmeter regulator

J. Adjustable wrench or 1 1/8-inch open-end wrench

II. Procedure

A. Put on eye protection and protective clothing

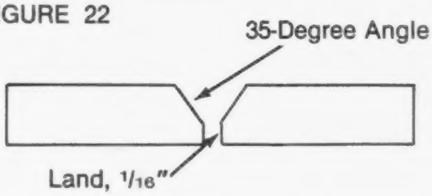
B. Inspect work area to see that it is free of combustible materials; determine location of nearest fire extinguisher

CAUTION

If working on an actual vehicle, disconnect battery and remove computer if vehicle is so equipped. Refer to vehicle service manual.

C. Bevel metal to be welded to a 35-degree angle, and grind edges to leave a 1/16-inch land as shown in Figure 22

FIGURE 22



JOB SHEET #6

D. Attach flowmeter regulator to shielding gas and adjust flow rate as outlined in Job Sheet #2

E. Complete equipment setup for short-circuit transfer

F. Adjust controls for metal thickness and wire diameter

G. Make a test bead on scrap metal and make necessary adjustments

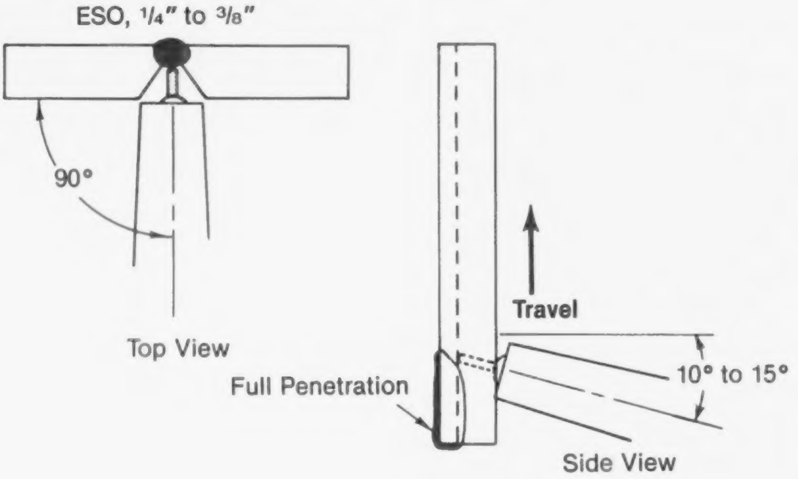
H. Position plates, leaving a 1/32-inch gap between them, and secure

(NOTE: The size of the gap will vary with the thickness of the metal. Check with your instructor.)

I. Tack-weld joint every 1 to 2 inches

J. Position gun at correct angle to joint and check ESO (Figure 23)

FIGURE 23



K. Squeeze gun trigger, form a puddle on one side of tack point so that it fuses with both edges of joint, and use a slight crescent weave to completely fuse both sides of joint as you weld its length

L. Crater and fill to end the weld

M. Place gun in safe place

N. Clean joint with wire brush as required

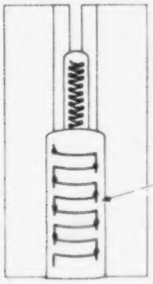
JOB SHEET #6

O. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter

P. Check ESO for start of fill-up bead and trim as necessary

Q. Reposition gun and use motion shown in Figure 24 to lay second pass over first bead

FIGURE 24



Note backstep.

R. Crater and fill to end the weld, place gun in a safe location, and clean and inspect second bead

S. Continue running beads until enough beads have been laid down to fill the joint even with surface of base metal

T. Check ESO for start of top bead and trim as necessary

U. Reposition gun and use weaving technique to place the top and last pass

V. Place gun in a safe location, and clean and inspect the top pass

W. Shut down equipment

X. Clean work area and retun equipment and materials to proper storage

MIG WELDING AND PLASMA CUTTING
UNIT III

JOB SHEET #7 — USE PLASMA CUTTING OUTFIT TO CUT ALUMINUM

I. Equipment and materials

A. $\frac{1}{8}$-inch or $\frac{1}{16}$-inch scrap aluminum

B. Protective clothing and eye protection

(NOTE: Be sure to wear the lens shade recommended by the plasma cutter manufacturer.)

C. Plasma cutting outfit, tip assembly, and instruction manual

D. Welding station equipped with opaque, nonflammable screens

E. Compressed air supply

F. Appropriate screwdriver

G. Wrench

II. Procedure

A. Put on protective clothing and eye protection

B. Set up power supply unit and attach cutting tip and shop or cylinder air supply according to manufacturer's instructions

CAUTION

Voltages in plasma cutting equipment are high enough to cause serious injury or possibly death. Be particularly careful around equipment when the covers are removed from the power supply unit.

C. Reinstall unit panels and cover; tighten all screws firmly

D. Clamp work cable to workpiece, making sure that workpiece is connected to an approved earth ground with a properly sized cable

CAUTION

Locate power supply unit in an open area where air can circulate freely through the vents. Allow at least 1 foot of clearance between the power supply and wall or other obstruction. The air around the power supply unit should be relatively free of dust, fumes, and excessive heat.

JOB SHEET #7

E. Adjust unit

1. Slowly open air (gas) cylinder valve
2. Place gas mode switch in the SETUP position
3. Place power switch in the OFF position
4. Plug power unit into wall receptacle
5. Place power switch in READY position

   (NOTE: The output light should light up indicating that the control circuits are energized.)

6. Adjust regulator to deliver 50 psi
7. Allow gas to flow for a few minutes to remove any condensation that may have accumulated during shutdown
8. Place gas mode switch in OPERATE position to shut off gas flow

F. Make cut

1. Touch tip of torch to workpiece (or bring to within 0.20 inch of workpiece) and hold at about a 15- to 30-degree angle to work
2. Depress torch switch

   (NOTE: Two seconds after depressing the switch, the plasma arc will begin cutting.)

3. Drag tip along line to be cut, holding torch at a 15- to 30-degree angle to work and moving tip at cutting speed within range recommended for type and thickness of metal being cut

   (NOTE: When cutting thicker materials [up to $^3/_{16}$-inch aluminum or $^1/_4$-inch stainless or carbon steel], immediately raise the torch to $^1/_{16}$-inch standoff after initiating the cutting arc and maintain a $^1/_{16}$-inch tip-to-work distance.)

4. End cut by releasing torch switch just before end of cut

G. Practice cutting process on various types and thicknesses of metal

H. Place power switch in OFF position

(NOTE: Pilot light will go out.)

I. Disconnect unit from wall receptacle

J. Clean work area and return equipment and materials to proper storage

ABR - 173-A

MIG WELDING AND PLASMA CUTTING
UNIT III

TEST

NAME ____ SCORE ________________

1. Match to their correct definitions terms associated with MIG welding and plasma cutting. Write the correct numbers in the blanks.

_____a. Basic measure of amount of electricity flowing past a point, as through a wire

_____b. Basic measure of strength of electricity flowing past a point, as through a wire

_____c. Distance that electrode extends beyond tip of welding gun

_____d. MIG welding process that uses a short arc length, low voltage and current, and small-diameter wire

_____e. Scum formed on surface of molten metal

_____f. Relationship between voltage and amperage in the operation of a MIG welder

_____g. Amount of time that an electrical device, such as a welder, may operate without suffering damage

_____h. Direction of electrical flow

_____i. Mixture of molten metal, melted electrode, and other fluid products of the welding process that splash out from weld

_____j. Measure of rate of flow of shielding gas in MIG welding

_____k. Measure of rate of feed for MIG electrode wire

_____l. Use of nonconducting materials to stop or reduce the flow of energy

_____m. Characteristic of a circuit that controls amount of amperage change possible

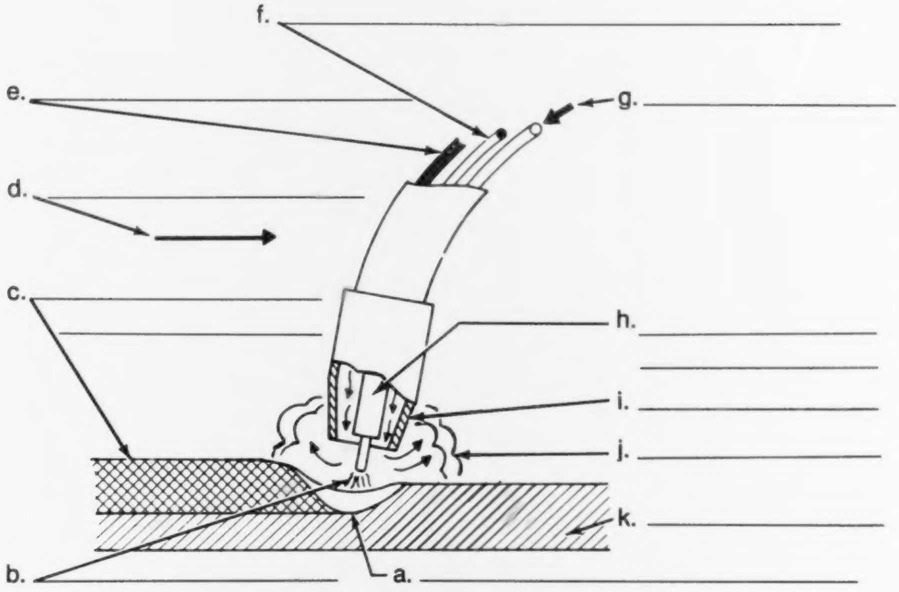
_____n. Characteristic of a circuit that controls amount of voltage change possible

_____o. High-temperature ionized gas

1. Short-circuit transfer
2. Dross
3. Electrode stickout (ESO)
4. Spatter
5. Amperage (current)
6. Voltage
7. Slope
8. Inductance
9. Resistance
10. Polarity
11. Duty cycle
12. Insulate
13. Plasma
14. Cubic feet per hour (cfh)
15. Inches per minute (ipm)

TEST

2. Label elements of the MIG welding process illustrated below.



3. Select from the following list characteristics of short-circuit transfer. Write an "X" in the blank before each correct answer.

______a. Is commonly used for thin metals, such as body metal, and for high-strength, low-alloy steel

______b. Requires specific gas

______c. Is commonly used for thick metals and for aluminum

______d. Uses relatively high voltage and current; operating voltages range from 26 volts to 35 volts

______e. Uses relatively low operating voltages and current; operating voltages range from 15 volts to 22 volts, depending on wire size and shielding gas

______f. Amperage is controlled by wire-feed speed

TEST

_____g. Has characteristic sizzling or buzzing sound that usually indicates proper adjustment of all elements involved

_____h. Metal transfer is made as a stream of tiny droplets moves across arc from electrode to weld

_____i. Is used frequently with large-diameter wires

_____j. Produces less heat in the base metal than spray-arc transfer method used for thicker metals

_____k. Metal does not transfer across arc, but melts off when electrode wire makes contact with base metal

_____l. Is used primarily for wires less than 0.045 inch in diameter

_____m. Frequently uses moderate slope adjustment to avoid spatter

4. State normal electrode stickout (ESO) for short-circuit transfer.

Normal ESO for short-circuit transfer — ______________________________

5. State the effect of increasing electrode stickout.

____

____

6. Match typical MIG welder controls to their correct functions. Write the correct numbers in the blanks.

Machine control functions

_____a. Reduces high-pressure cylinder gas to low-pressure gas so its flow rate can be controlled to the welding gun as measured in cfh

_____b. Transports power to trigger-operated gun

_____c. Controls current and voltage used in the basic MIG processes

_____d. Starts or stops flow of wire, shielding gas, and coolant to weld zone

_____e. Varies and controls speed at which wire is fed to welding arc in relation to amperage and wire-feed speed

1. Power supply
2. Wire feeder
3. Cable assembly
4. Gun
5. Flowmeter regulator

TEST

Electrical control functions

______a. Completes circuit through wire feed and functions as an on/off device for wire feed

______b. Increases or decreases rate of resistance change

______c. Starts or stops electrical power to welder

______d. Indicates voltage levels

______e. Changes polarity from reverse to straight so that meters for amperes and volts can be properly read

______f. Indicates amperage levels

______g. Controls wide-range voltage selection, such as 12 volts to 28 volts for low range and 20 volts to 35 volts for high range

______h. Controls arc-on time in short-circuit welding to control puddle fluidity and produce a flat, smooth weld bead

______i. Fine tunes voltage selection within wide-range setting

1. On/off switch
2. Voltage range selector
3. Fine voltage control
4. Power supply voltmeter
5. Power supply ammeter
6. Slope control
7. Polarity switch
8. Contactor control
9. Inductance control

Wire-feeder control functions

______a. Controls power input into wire-feed mechanism

______b. Permits purging of shielding gas through gun without having wire feed at the same time

______c. Increases or decreases burn-back on ESO

______d. Advances wire for setup without activating other components

______e. Functions as a dual control to regulate wire-feed rate in inches per minute in relation to amperage

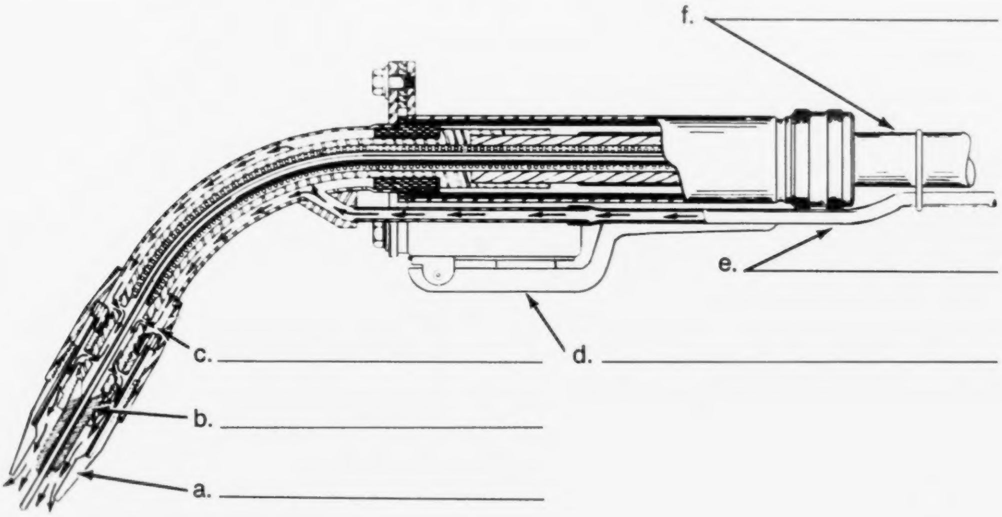
______f. Sets and adjusts voltage and amperage in the wire-feed mechanism

______g. Routes current through a timer to provide a specific time for trigger activation, regardless of how long or how briefly the trigger is held

1. On/Off switch
2. Amp/ipm switch
3. Contactor dropout control
4. Purge control
5. Wire-inch switch
6. Wire-feed voltage and amperage control
7. Spot weld function switch

TEST

7. Label the parts of the MIG welding gun illustrated below.



8. Match MIG gun tip parts to their correct uses. Write the correct numbers in the blanks.

_____a. Copper device used to guide wire to weld; available in standard, heavy-duty, and tapered designs

_____b. Device used to insulate nozzle from welding current and to hold nozzle in place

_____c. Specially shaped device used to direct and hold shielding gas around weld zone; may be standard, tapered for tight places, or heavy-duty for continuous welding

_____d. Copper device that spreads shielding gas out so that it flows evenly over electrode wire and weld zone

1. Contact tip
2. Gas diffuser
3. Nozzle insulator
4. Nozzle

9. Explain the meaning of each element in the electrode-wire classification code.

a. **E** — ____________________

b. **R** — ____________________

c. **Numbers** — ____________________

d. **S** — ____________________

e. **T** — ____________________

f. **Final letter/number** — ____________________

TEST

10. State guidelines for handling and storing electrode wire spools.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

11. Select from the following list safety guidelines for working with electrode wire. Write an "X" in the blank before each correct answer.

_____a. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye

_____b. Always wear leather gloves when handling electrode wire

_____c. Wear a particle mask or respirator and avoid breathing the toxic fumes released from electrode wire

_____d. Make sure that you have the correct spool or coil before loading and cutting tie wires

_____e. Hold free end of electrode wire firmly to avoid backlash during reloading procedure; failure to do so could ruin an entire spool or coil

_____f. Position coils close to reel before lifting, and lift with your legs, not with your back

_____g. Visually inspect interior of gun to make sure that it is unobstructed

_____h. Never look into a gun while feeding wire through it

_____i. Never point the gun at yourself or at anyone else

_____j. Place a finger or hand over contact tip to see whether or not wire is feeding properly

TEST

12. State charcteristics of basic MIG welding techniques.

Push technique (forehand technique)

a. ______________________________

b. ______________________________

c. ______________________________

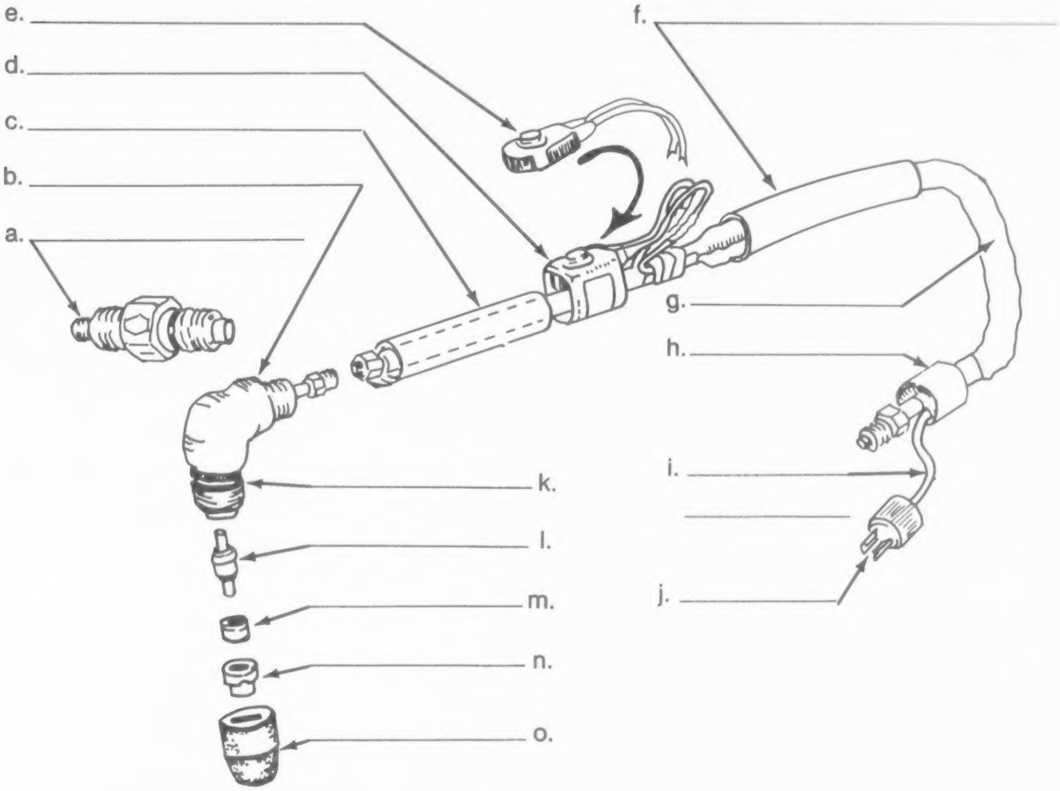
Pull technique (backhand or drag technique)

a. ______________________________

b. ______________________________

c. ______________________________

13. Label the parts of the plasma-cutting torch assembly illustrated below.



TEST

14. Match common plasma cutting problems to their probable causes. Write the correct numbers in the blanks. Numbers will be used more than once. Some blanks may contain more than one number.

______a. Cutting speed too fast

______b. Heavy spatter

______c. Incorrect cutting speed

______d. Loose connections

______e. Improper gas pressure

______f. Damaged cutting tip

______g. Electrode not straight or centered

______h. Faulty tip or electrode

______i. Cutting speed too fast or too slow

______j. Cutting speed too slow

______k. Electrode and/or cutting tip in poor condition

______l. Loose cutting tip

______m. Gas pressure too low

1. Insufficient penetration
2. Main arc extinguishes
3. Dross formation
4. Double arcing (damaged tip orifice)
5. Uneven arc
6. Unstable cutting conditions
7. Main arc does not strike
8. Poor consumable life

(NOTE: Test items 15 and 16 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

15. Determine correct duty-cycle requirements.

16. Demonstrate the ability to

    a. Set up spool-type wire feeder for MIG welding.

    b. Set up flowmeter regulator for MIG shielding gases.

    c. Use short-circuit transfer to lay stringer beads on mild steel in the flat position.

    d. Use short-circuit transfer to construct a fillet weld lap joint on mild steel in the flat position.

    e. Use short-circuit transfer to construct a fillet weld T-joint on mild steel in the horizontal position.

    f. Use short-circuit transfer to construct a V-groove butt joint on mild steel in the vertical position.

    g. Use plasma cutting outfit to cut aluminum.

MIG WELDING AND PLASMA CUTTING
UNIT III

ANSWERS TO TEST

1. a. 6
   b. 5
   c. 3
   d. 1
   e. 2
   f. 7
   g. 11
   h. 10
   i. 4
   j. 14
   k. 15
   l. 12
   m. 9
   n. 8
   o. 13

2. a. Molten weld metal
   b. Arc
   c. Solidified weld metal
   d. Travel
   e. Current conductor
   f. Solid wire electrode
   g. Shielding gas
   h. Wire guide and contact tube
   i. Gas nozzle
   j. Shielding gas
   k. Work

3. a, e, f, j, k, l, m

4. ¼ inch to ⅜ inch

5. Decreases amperage and increases voltage

6. **Machine control functions**
   a. 5
   b. 3
   c. 1
   d. 4
   e. 2

   Electrical control functions
   a. 8
   b. 6
   c. 1
   d. 4
   e. 7
   f. 5
   g. 2
   h. 9
   i. 3

   Wire-feeder control functions
   a. 1
   b. 4
   c. 3
   d. 5
   e. 2
   f. 6
   g. 7

ANSWERS TO TEST

7. a. Gas nozzle
   b. Contact tube
   c. Gas-cooled chamber
   d. Switch
   e. Gas line
   f. Power cable

8. a. 3
   b. 4
   c. 1
   d. 2

9. a. Indicates electrode
   b. Indicates that the filler metal may be used as an electrode or welding rod
   c. Indicate minimum tensile strength in multiples of 1000 psi
   d. Indicates a bare, solid electrode or rod
   e. Indicates a flux-cored, tubed electrode
   f. Indicates special chemical compositions of electrode wire

10. a. Do not unseal spools or coils until they are needed for immediate use
    b. Store electrode wires in a dry place
    c. Use spools or coils as soon after opening as possible
    d. Cover or reseal remaining wire prior to storage

11. a, d, e, f, h, i

12. **Push technique (forehand technique)**
    a. Electrode points in direction of travel
    b. Technique decreases penetration and gives a wide, flat bead
    c. Technique is used mostly on thick metals

    Pull technique (backhand or drag technique)
    a. Electrode points opposite direction of travel
    b. Technique increases penetration; gives a convex, narrow bead; provides a more stable arc; and leaves less spatter on workpiece
    c. Technique is used mostly on thin metals

13. a. Pencil head
    b. 75-degree head
    c. Handle
    d. Switchband
    e. Switch
    f. Flex support
    g. Sheath
    h. Boot
    i. Strain relief
    j. Plug
    k. Power cable
    l. O-ring
    m. Electrode
    n. Swirl baffle
    o. Tip
    p. Shield

ANSWERS TO TEST

14. a. 1
    b. 4
    c. 6
    d. 6, 7
    e. 1, 3, 8
    f. 1, 4, 5
    g. 5
    h. 3
    i. 3
    j. 2
    k. 6
    l. 4
    m. 4

15. Evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

SURFACE PREPARATION
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to prepare interior and exterior vehicle surfaces for metal repair. The student will show this knowledge by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with surface preparation.
2. State the purpose of preparing a surface for metal repair.
3. List the advantages of preparing a surface for metal repair.
4. Arrange in order the basic steps in surface preparation for metal repair.
5. State the amount of exterior and interior surface area that needs to be prepared.
6. Name moldings and trim that may need to be removed in surface preparation.
7. Demonstrate the ability to
    a. Prepare exterior and interior surfaces.
    b. Remove polysilicone coating from a panel.
    c. Remove rock-guard coating from a panel.

SURFACE PREPARATION
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Transparency masters

      1. TM #1 — Surface Area to Be Cleaned

      2. TM #2 — Front Moldings and Trim

      3. TM #3 — Exterior Side Moldings and Trim

      4. TM #4 — Typical Interior Door Trim

      5. TM #5 — Interior Quarter Trim Panel

      6. TM #6 — Rear Moldings and Trim

   D. Information sheet

   E. Job sheets

      1. Job Sheet #1 — Prepare Exterior and Interior Surfaces

      2. Job Sheet #2 — Remove Polysilicone Coating from a Panel

      3. Job Sheet #3 — Remove Rock-Guard Coating from a Panel

   F. Test

   G. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials needed to supplement unit.

      1. Equipment and materials for job sheet procedures

      2. Transparencies and competency profiles

SUGGESTED ACTIVITIES

(NOTE: Transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Explain the importance of correctly preparing a surface for metal repair.
- Discuss unit and specific objectives.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with surface preparation for metal repair.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Sections II and III to discuss the purpose and advantages of preparing a surface for metal repair.

   SUGGESTIONS:

   - Show students examples of paint failure caused by wax and grease being forced into the pores of metal.
   - Have students assess the extent of damage to an unprepared panel and compare their assessments to the damage revealed on the same panel after surface preparation.
   - Demonstrate what happens to sandpapers and abrasive discs when they are used on unprepared surfaces.

3. Use Information Sheet, Section IV to explain the proper sequence of the basic steps used in surface preparation.

   SUGGESTION:

   - Explain the logic of peforming the steps in this order or sequence.

4. Use Information Sheet, Section V to discuss the amount of surface area that needs to be prepared.

SUGGESTED ACTIVITIES

SUGGESTION:

- Use Transparency #1 to illustrate your discussion.

5. Use Information Sheet, Section VI to review molding and trim that may need to be removed in surface preparation.

SUGGESTION:

- Use Transparencies #2 through #6 to illustrate your discussion.
- Explain to students that molding and trim are fastened in many different ways on the different makes and models of vehicles. Caution students against recklessly removing molding and trim. Explain that they must first analyze and determine the method of attachment and then follow service manual instructions for removal.
- Show students molding and trim fastened in different manners on various makes and models of vehicles.

6. Demonstrate and discuss Job Sheets #1 through #3.

7. Have students complete Job Sheets #1 through #3.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest as necessary.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing.* New York: McGraw-Hill Book Company/Gregg Division, 1980.

B. Duenk, Lester G., W. Randolph Williams, and Clarence A. Brooks. *Auto Body Repair.* Peoria, Illinois: Chas. A. Bennett Co., Inc., 1977.

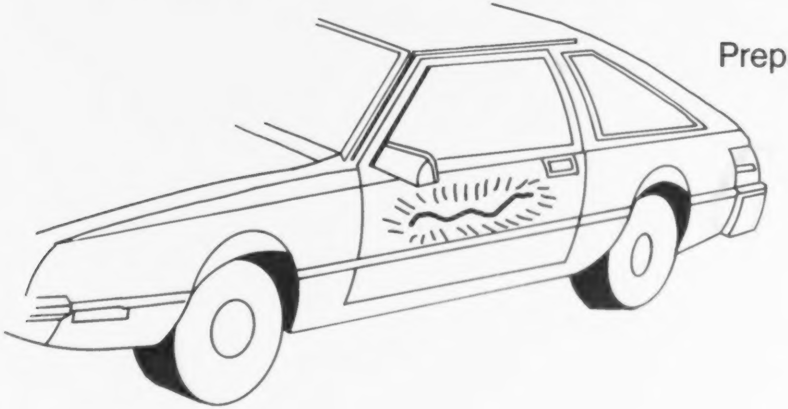
C. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

D. *The New Science of Unibody Repair: Technician Workbook.* Milwaukee, Wisconsin: Blackhawk Applied Power, Inc., Automotive Division, 1982.

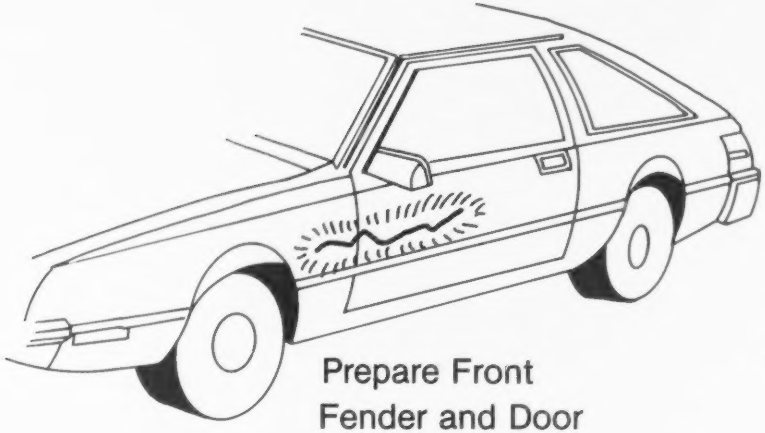
E. Rhone, L.C., and H. David Yates. *Total Auto Body Repair,* 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

F. Tait, Alex, A.G. Deroche, and N.N. Hildebrand. *The Principles of Autobody Repairing and Repainting.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971.

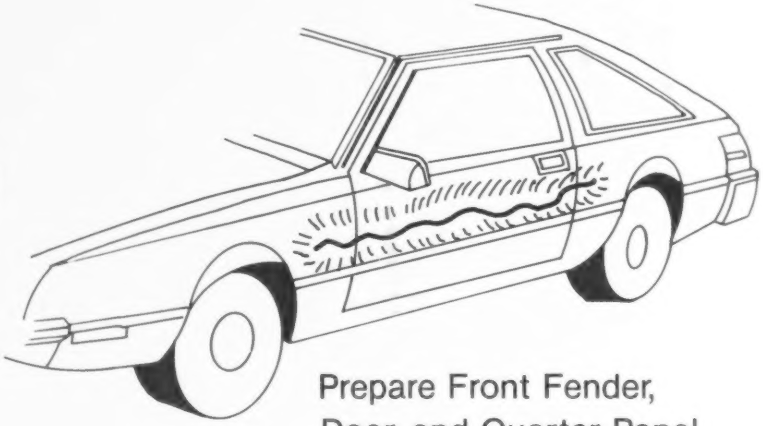
Surface Area to Be Cleaned



Prepare Door



Prepare Front
Fender and Door



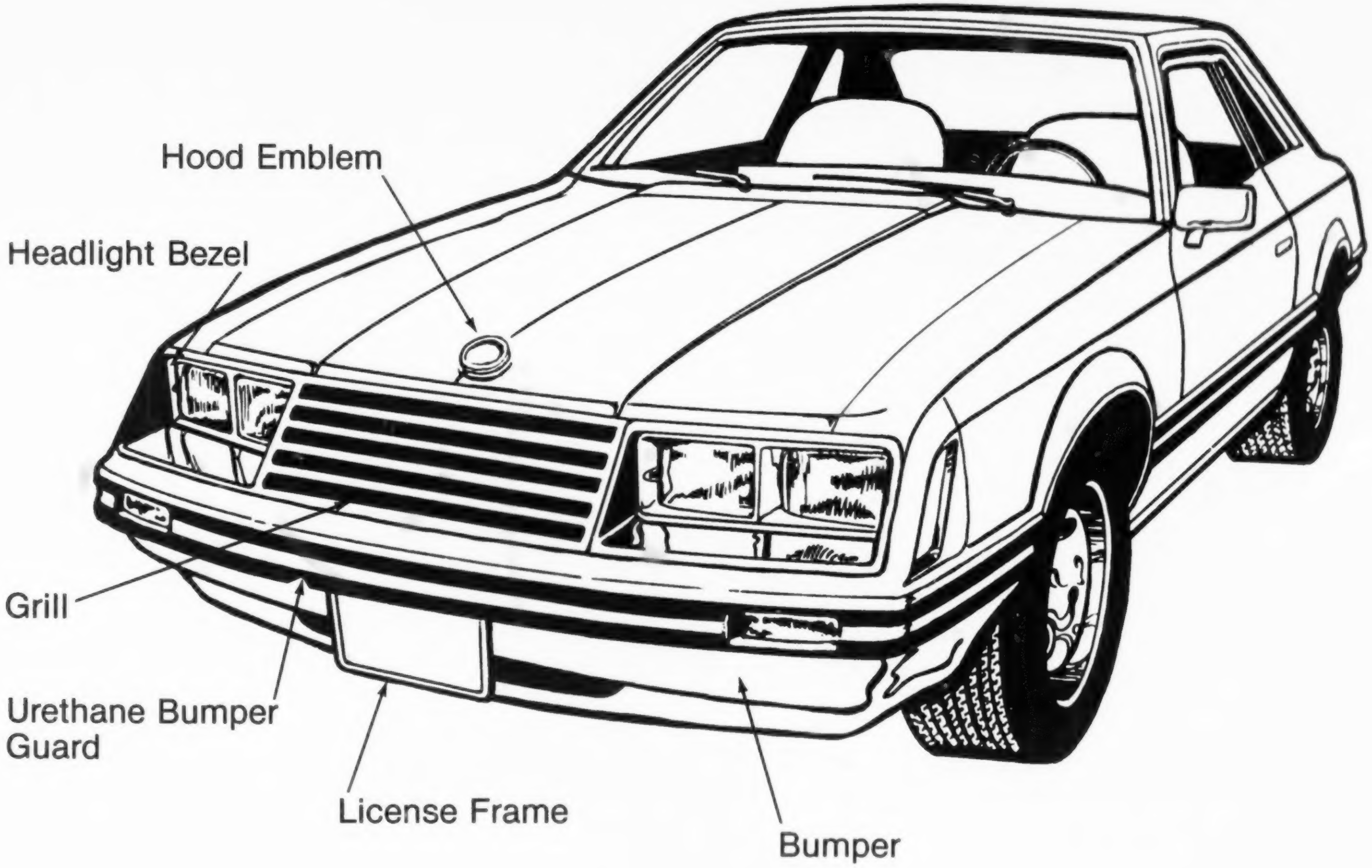
Prepare Front Fender,
Door, and Quarter Panel

Adapted with permission of the Chrysler Corporation.

TM #1

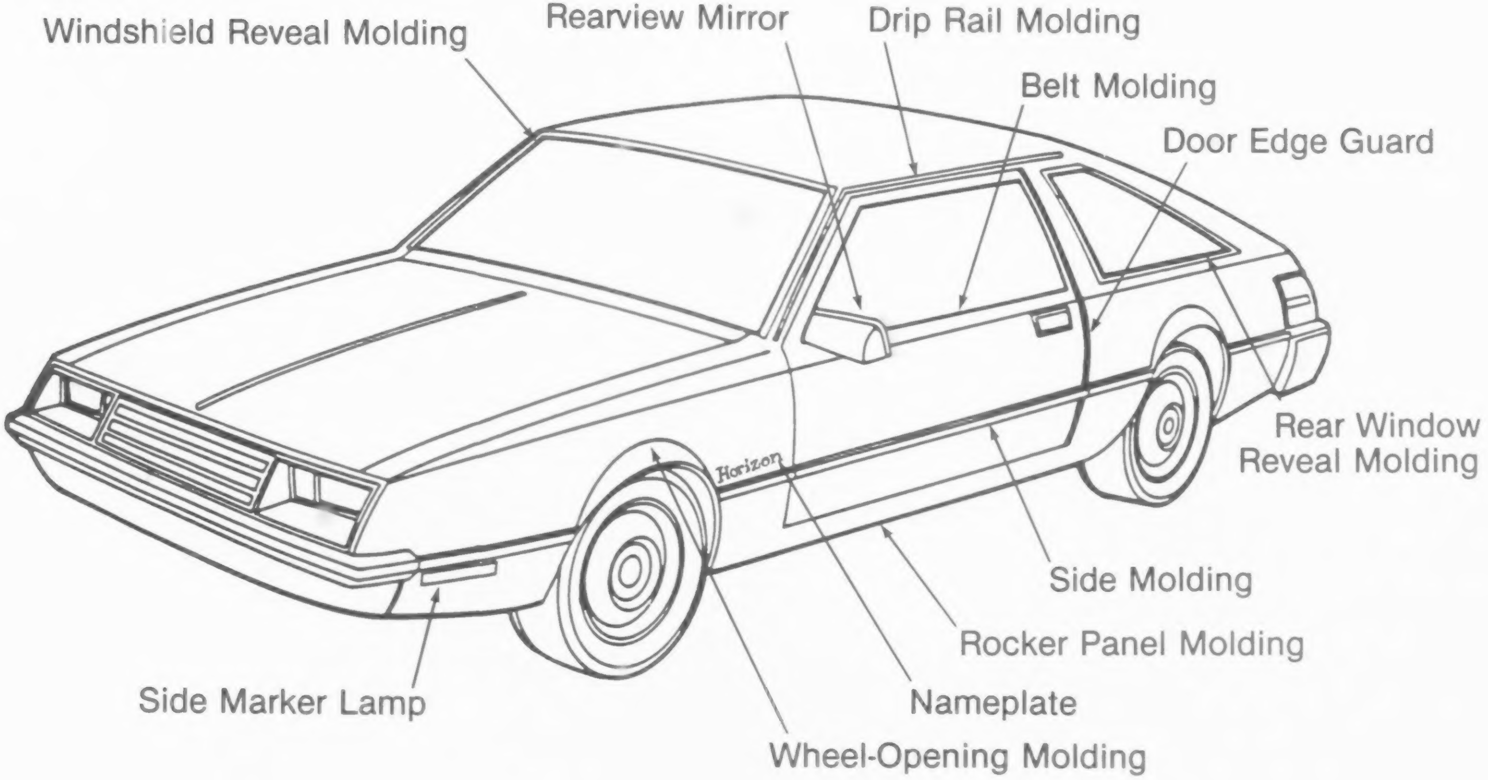
ABR - 7-B

Front Moldings and Trim



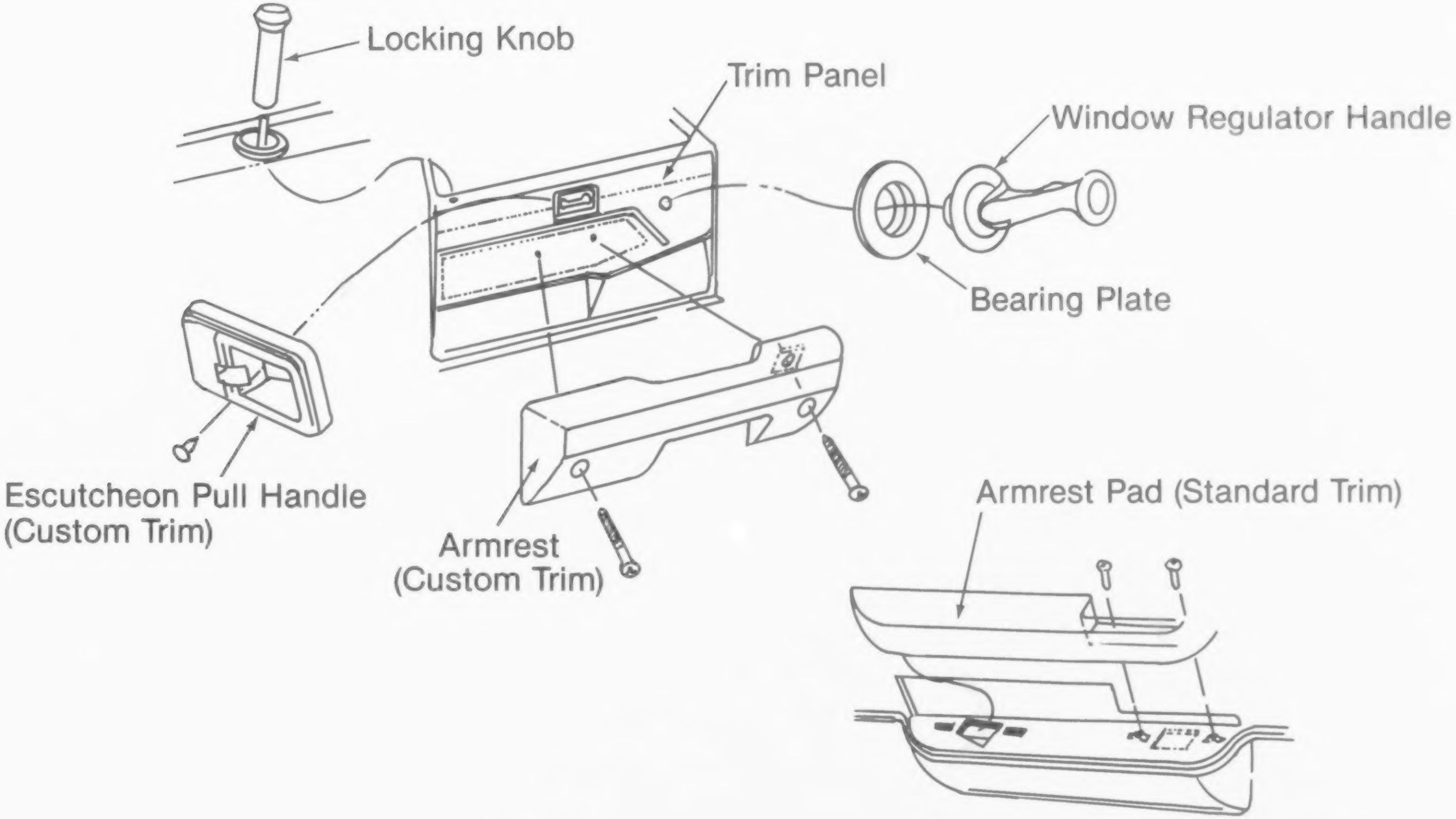
From the *New Science of Unibody Repair,* copyright 1982. Used with permission of Blackhawk Applied Power, Inc., Automotive Division.

Exterior Side Moldings and Trim



Adapted with permission of the Chrysler Corporation.

Typical Interior Door Trim

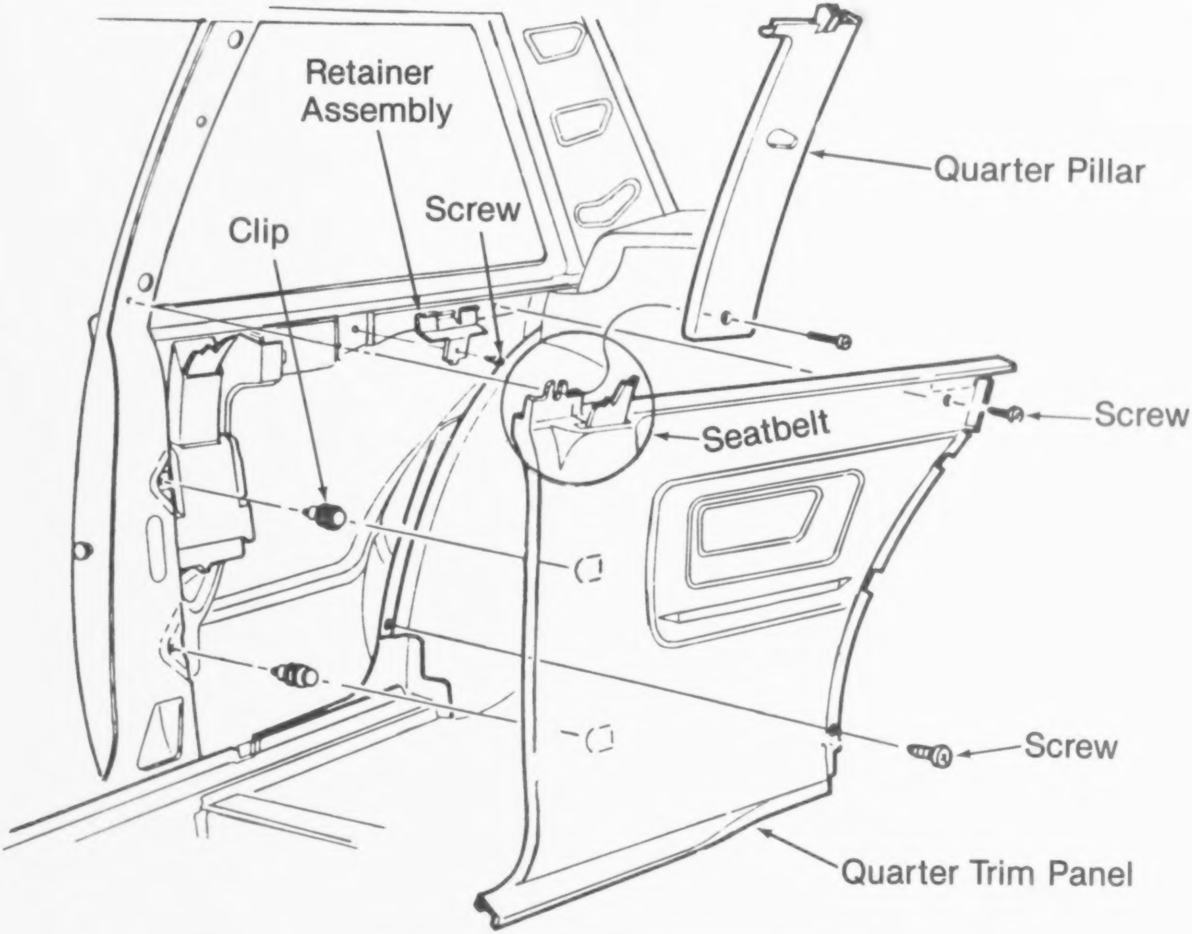


Used with permission of General Motors Corporation, Chevrolet Motor Division.

TM #4

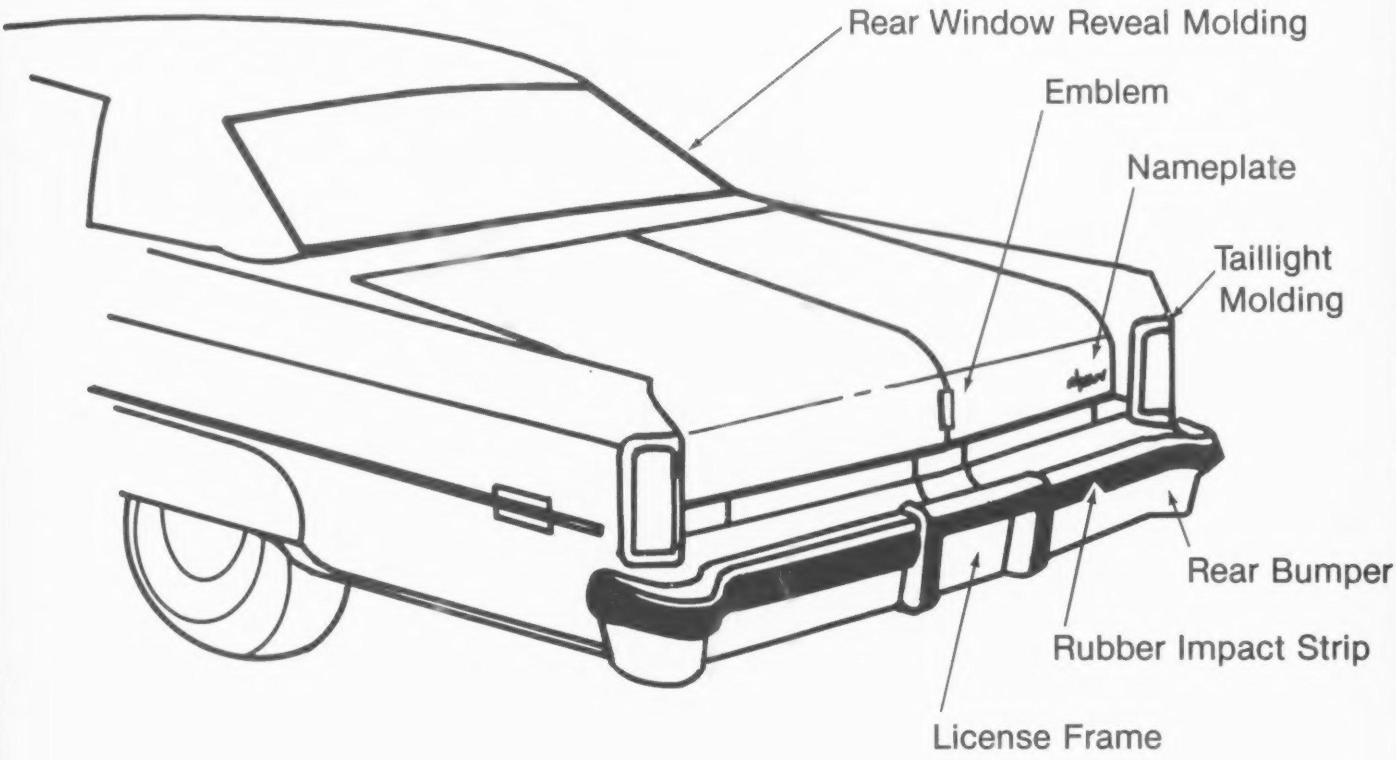
ABR - 13-B

Quarter Trim Panel



Adapted with permission of Customer Service Division, Ford Motor Company.

Rear Moldings and Trim



SURFACE PREPARATION
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Surface preparation — Process of cleaning vehicle's exterior and interior metal surfaces prior to roughout and metal finishing

   B. Panel exterior — Outer surface of any body panel

   C. Panel interior — Inner surface of any body panel

   D. Trim — Any part that is attached to vehicle body after it is painted

   EXAMPLES: Door side molding, reveal molding, nameplates and decorative emblems

   E. Molding — Trim strip used for ornamentation or finishing

   F. Detergent — Synthetic cleaning agent resembling soap in its ability to suspend oil and hold dirt

   G. Wax and grease remover — Solution used to remove wax, grease, oil, and road tar from vehicle panels

   H. Undercoating — Waterproof, rubberized or tar-based substance applied to undersurface of vehicle

   I. Rust coating — Substance containing petroleum thinners applied to panel interior to slow rust formation and oxidation of metal

   J. Rock-guard coating — Protective acrylic substance applied to lower part of panel exterior to prevent finish from being chipped by stones or gravel

   K. Polysilicone coating — Transparent plastic substance applied over paint to protect paint from the weather and thus prevent oxidation and fading of finish

   EXAMPLE: Polyglycoat

II. Purpose of surface preparation — To provide a clean surface for metal repair

III. Advantages of surface preparation

(NOTE: Proper surface preparation is a hallmark of quality work and cuts costs.)

   A. Reveals extent of damage

   B. Prolongs life of sandpapers and abrasive discs used in metal finishing

INFORMATION SHEET

C. Helps metal finisher by removing contaminates that would interfere with hammer and dolly techniques

D. Helps prevent paint failure caused by wax and grease being forced into pores of metal

IV. Sequence of basic steps in surface preparation for metal repair

A. Wash panel exteriors with detergent and water

B. Protect moldings and trim in areas adjacent to preparation area

C. Remove moldings and trim from preparation area

D. Prepare panel exterior

E. Prepare panel interior

V. Amount of surface area that needs to be prepared

A. Panel exterior — Prepare entire panel or panels

(NOTE: Additional preparation will be needed before refinishing.)

B. Panel interior — Prepare at least 6 inches beyond damage in all directions

VI. Moldings and trim that may need to be removed in surface preparation

A. Front

1. Hood moldings and trim
2. Grill
3. Front bumper and/or bumper guard
4. Headlight bezel
5. Front fender belt
6. License frame

B. Side (exterior)

1. Windshield reveal molding
2. Drip rail molding
3. Rocker panel

INFORMATION SHEET

4. Rear quarter panel
5. Rear quarter belt
6. Back window reveal molding
7. Wheel opening moldings
8. Nameplates and emblems
9. Door reveal molding
10. Door belt
11. Door edge guard

C. Side (interior)

1. Door handle or pull
2. Armrest
3. Window crank or switch
4. Rearview mirror control
5. Quarter trim panel

   (NOTE: The rear seat and back cushion must be removed before the interior quarter panel can be removed.)

D. Rear

1. Deck lid molding
2. Rear bumper and/or bumper guard
3. Taillight trim
4. Taillight assemblies
5. Emblems and nameplates
6. Rear window reveal molding

SURFACE PREPARATION
UNIT I

JOB SHEET #1 — PREPARE EXTERIOR AND INTERIOR SURFACES

I. Equipment and materials

A. Eye protection

B. Rubber gloves

C. Water pail

D. Sponge

E. Detergent

F. Wax and grease remover

G. #1 or #2 Phillips screwdriver

H. ¼-inch standard screwdriver

I. Combination-end wrenches

J. ¼-inch ratchet set

K. Oxyacetylene torch and appropriate tip

L. Full-face shield and protective clothing for use with oxyacetylene equipment

M. Masking tape

(NOTE: Special wide, thick tape is available from various manufacturers.)

N. Clean cloths and chamois cloths

O. Scraper or putty knife

II. Procedure

A. Clean exterior surfaces

1. Put on eye protection and rubber gloves

2. Make solution of detergent and water

3. Wash exterior panels with water and detergent solution, washing small sections of 2 or 3 feet at a time and dipping cloth in detergent solution frequently to wash out excess dirt

JOB SHEET #1

4. Rinse panels with clean water, and dry with a clean cloth or chamois

5. Apply several layers of masking tape to moldings that will not be removed

6. Remove moldings and trim that will interfere with repair process

7. Read instructions and cautions on wax and grease remover label

8. Apply wax and grease remover to clean, dry cloth; apply liberally to panel surface in small sections of 2 or 3 feet at a time

   CAUTION
   Avoid inhaling the fumes from the wax and grease remover.

9. While surface is still wet, fold a clean, dry cloth and wipe dry

   (NOTE: You may have to repeat steps 8 and 9 more than once if the surface has heavy road-tar buildup.)

B. Clean interior surface

1. Remove any hardware that will interfere with cleaning process

2. Put on eye protection and rubber gloves

3. If surface is not undercoated, wash with wax and grease remover, following instructions and cautions on remover label

4. If surface is undercoated, perform the following steps under the supervision of your instructor

   a. Put on full-face shield and protective clothing

   b. Set up oxyacetylene equipment

   c. Turn on oxyacetylene equipment, light, and adjust flame

   d. Warm exterior surface of panel with oxyacetylene torch

      CAUTION
      Do not burn paint.

   e. Turn off torch

   f. Scrape off undercoating with scraper, reheating stubborn areas as necessary

JOB SHEET #1

CAUTION
Undercoating will be hot. Take care to avoid burns.

   g. Turn off oxyacetylene equipment

   h. Wash surface with wax and grease remover, following instructions and cautions on remover label

5. While surface is still wet, fold a clean dry cloth and wipe dry

C. Clean work area and return equipment and materials to proper storage

SURFACE PREPARATION
UNIT I

JOB SHEET #2 — REMOVE POLYSILICONE COATING FROM A PANEL

I. Equipment and materials

   A. Polysilicone remover

   B. Spray bottle

   C. Rubber gloves

   D. Water

   E. Clean cloths

   F. Eye protection

II. Procedure

(NOTE: Because polysilicone coating cannot be seen with the naked eye, the technician must check with the vehicle owner or dealer to determine whether it has been applied to the vehicle. Some vehicles may have a window decal indicating that a polysilicone coating has been applied.)

   A. Set up work area in well-ventilated location

   B. Read all instructions and cautions on polysilicone remover labels

   C. Put on eye protection and rubber gloves

   D. Pour measured amount of polysilicone remover in spray bottle and dilute with water as recommended by manufacturer

   E. Screw spray nozzle onto bottle and shake bottle well to mix water and remover

   F. Apply remover to coated surface by misting (spraying) entire surface

CAUTION

Avoid breathing vapor or spray mist. Do not use polysilicone remover on fresh paint, and rinse remover off any glass surfaces with water.

(NOTE: Polysilicone remover must be *sprayed on* for removal of polysilicone coatings.)

JOB SHEET #2

G. Let remover stand for 4 to 6 minutes

H. Wipe off remover with a clean cloth

I. Wipe a second time with another clean cloth

(NOTE: The surface should now be free of polysilicone coating.)

J. Clean work area and return equipment and materials to proper storage

SURFACE PREPARATION
UNIT I

JOB SHEET #3 — REMOVE ROCK-GUARD COATING FROM A PANEL

I. Equipment and materials

- A. Heat gun and stand
- B. Welding gloves
- C. Scraper or putty knife
- D. Lacquer thinner
- E. Rubber gloves
- F. Clean cloths
- G. Eye protection

II. Procedure

- A. Set up work area in well-ventilated location
- B. Put on welding gloves and eye protection
- C. Connect heat gun to power source, switch on, and allow to heat up

CAUTION

Heat guns put out extreme heat and can cause burns if improperly handled. Follow manufacturer's instructions and cautions, and handle with care.

- D. Aim heat gun at coating to be removed and work slowly back and forth over a section of panel about 1 foot long

CAUTION

Avoid breathing topic vapors released by heating.

- E. Switch gun to cool air and place on stand in safe area
- F. Run length of heated area with scraper or putty knife to scrape off heated coating

JOB SHEET #3

CAUTION
Be careful not to let heated coating contact the skin, or burns could result.

G. Repeat process, heating coating in 1-foot sections and scraping until all coating is removed

H. Disconnect heat gun from power source

I. Remove welding gloves and put on rubber gloves

J. Let worked surface cool to normal temperature

K. Apply lacquer thinner to clean cloth

CAUTION
Lacquer thinner is highly explosive. Do not expose to heat or flame.

L. Wipe surface with this solvent, working in small areas of about 1 foot at a time, until all traces of coating are removed

M. Wipe surface a final time with a clean, dry cloth to remove solvent

N. Clean work area and return equipment and materials to proper storage

SURFACE PREPARATION
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with surface preparation. Write the correct numbers in the blanks.

_____a. Outer surface of any body panel

_____b. Waterproof, rubberized or tar-based substance applied to undersurface of vehicle

_____c. Transparent plastic substance applied over paint to protect paint from the weather and thus prevent oxidation and fading of finish

_____d. Process of cleaning vehicle's exterior and interior metal surfaces prior to roughout and metal finishing

_____e. Inner surface of any body panel

_____f. Trim strip used for ornamentation or finishing

_____g. Any part that is attached to vehicle after it is painted

_____h. Solution used to remove wax, grease, oil, and road tar from vehicle panels

_____i. Substance containing petroleum thinners applied to panel interior to slow rust formation and oxidation of metal

_____j. Protective acrylic substance applied to lower part of panel exterior to prevent finish from being chipped by stones or gravel

_____k. Synthetic cleaning agent resembling soap in its ability to suspend oil and hold dirt

1. Rust coating
2. Polysilicone coating
3. Undercoating
4. Rock-guard coating
5. Trim
6. Molding
7. Panel exterior
8. Panel interior
9. Surface preparation
10. Wax and grease remover
11. Detergent

2. State the purpose of preparing a surface for metal repair.

____

____

TEST

3. List three advantages of preparing a surface for metal repair.

   a. ______________________________

   ____

   b. ______________________________

   ____

   c. ______________________________

   ____

4. Arrange in order the basic steps in preparing a surface for metal repair. Write a "1" before the first step, a "2" before the second step, and so on.

   _____a. Protect moldings and trim in areas adjacent to preparation area

   _____b. Remove moldings and trim from preparation area

   _____c. Prepare panel interior

   _____d. Prepare panel exterior

   _____e. Wash panel exteriors with detergent and water

5. State the amount of exterior and interior surface area that needs to be prepared.

   a. Panel exterior — ______________________________

   ____

   b. Panel interior — ______________________________

   ____

6. Name moldings and trim that may need to be removed in surface preparation.

   a. Front (name four)

      1) ______________________________

      2) ______________________________

      3) ______________________________

      4) ______________________________

TEST

b. Side (exterior) (name six)

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

6) ______________________________

c. Side (interior) (name three)

1) ______________________________

2) ______________________________

3) ______________________________

d. Rear (name three)

1) ______________________________

2) ______________________________

3) ______________________________

(NOTE: Test question 7 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

7. Demonstrate the ability to

   a. Prepare exterior and interior surfaces.

   b. Remove polysilicone coating from a panel.

   c. Remove rock-guard coating from a panel.

SURFACE PREPARATION
UNIT I

ANSWERS TO TEST

1. a. 7
   b. 3
   c. 2
   d. 9
   e. 8
   f. 6
   g. 5
   h. 10
   i. 1
   j. 4
   k. 11

2. To provide a clean surface for metal repair

3. Answer should include any three of the following
   a. Reveals extent of damage
   b. Prolongs life of sandpapers and abrasive discs used in metal finishing
   c. Helps metal finisher by removing contaminates that would interfere with hammer and dolly technique
   d. Helps prevent paint failure caused by wax and grease being forced into pores of metal

4. a. 2
   b. 3
   c. 5
   d. 4
   e. 1

5. a. Panel exterior — Prepare entire panel or panels
   b. Panel interior — Prepare at least 6 inches beyond damage in all directions

6. a. Front (answer should include any four of the following)
      1) Hood moldings and trim
      2) Grill
      3) Front bumper and/or bumper guard
      4) Headlight bezel
      5) Front fender belt
      6) License frame

   b. Side (exterior) (answer should include any six of the following)
      1) Windshield reveal molding
      2) Drip rail molding
      3) Rocker panel
      4) Rear quarter panel

ANSWERS TO TEST

    5) Rear quarter belt
    6) Back window reveal molding
    7) Wheel opening moldings
    8) Nameplates and emblems
    9) Door reveal molding
    10) Door belt
    11) Door edge guard

c. Side (interior) (answer should include any three of the following)
    1) Door handle or pull
    2) Armrest
    3) Window crank or switch
    4) Rearview mirror control
    5) Door trim panel
    6) Quarter trim panel

d. Rear (answer should include any three of the following)
    1) Deck lid molding
    2) Rear bumper and/or bumper guard
    3) Taillight trim
    4) Taillight assemblies
    5) Emblems and nameplates
    6) Rear window reveal molding

7. Performance skills evaluated to the satisfaction of the instructor

ROUGHOUT
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to use basic straightening methods to rough out and align damaged vehicle panels and components. The student will show this knowledge by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with vehicle roughout.
2. Arrange in order the steps in assessing auto-body metal damage.
3. State the purpose of aligning detachable parts.
4. Label the basic parts of an impact-absorbing bumper assembly.
5. State safety rules to follow when handling hydraulic energy absorbers.
6. List factors to consider when roughing out auto-body sheet metal.
7. Describe the effects of bending auto-body sheet metal.
8. Identify classes of metal damage.
9. List basic metal-straightening methods.
10. Match basic metal-straightening methods to their correct applications.
11. State guidelines for use and care of hydraulic rams and power jacks.
12. Arrange in order the basic steps in repairing extensive metal damage.
13. Discuss clues to determining direction of damage.
14. Demonstrate the ability to
    a. Use hammer and dolly to rough out a panel.
    b. Use bumping or slapping spoon to rough out a panel.
    c. Use pull rods or slide hammer to rough out a panel.
    d. Use pry picks or body spoon to rough out a panel.

OBJECTIVE SHEET

e. Use vacuum cups to rough out a panel.

f. Use pull tabs to rough out a panel.

g. Use hydraulic ram and power jack to rough out a panel.

h. Align a hood.

i. Align a fender.

j. Align a door.

k. Align a deck lid and check for proper seal.

l. Inspect, test, and align a hydraulic impact-absorbing bumper.

ROUGHOUT
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Supplement #1 — How Impact-Absorbing Bumper Systems Work

   D. Transparency masters

      1. TM #1 — Work Hardening

      2. TM #2 — Stretch

      3. TM #3 — Typical Impact-Absorbing Bumper Assembly

      4. TM #4 — Rolled Buckle

      5. TM #5 — Hydraulic Body Jack and Accessories for Basic Straightening Jobs

      6. TM #6 — Picking

   E. Information sheet

   F. Job sheets

      1. Job Sheet #1 — Use Hammer and Dolly to Rough Out a Panel

      2. Job Sheet #2 — Use Bumping or Slapping Spoon to Rough Out a Panel

      3. Job Sheet #3 — Use Pull Rods or Slide Hammer to Rough Out a Panel

      4. Job Sheet #4 — Use Pry Picks or Body Spoon to Rough Out a Panel

      5. Job Sheet #5 — Use Vacuum Cups to Rough Out a Panel

      6. Job Sheet #6 — Use Pull Tabs to Rough Out a Panel

      7. Job Sheet #7 — Use Hydraulic Ram and Power Jack to Rough Out a Panel

      8. Job Sheet #8 — Align a Hood

      9. Job Sheet #9 — Align a Fender

SUGGESTED ACTIVITIES

10. Job Sheet #10 — Align a Door
11. Job Sheet #11 — Align a Deck Lid and Check for Proper Seal
12. Job Sheet #12 — Inspect, Test, and Align a Hydraulic Impact-Absorbing Bumper

G. Test

H. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Order or obtain materials to supplement unit.

1. Filmstrips

a. *Auto Body: Minor Repair*

b. *Auto Body Repair* (series)

1) "Roughing and Shaping Open and Enclosed Areas"
2) "Roughing, Shaping, and Finishing Open Metal Areas"
3) "Roughing, Shaping, and Plastic Finishing Enclosed Metal Areas"

(NOTE: Filmstrips *a* and *b* are available from Teaching Aids, Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321.)

c. *Autobody Repair: Metal Work* (series)

1) "Hand Tools and Power Equipment"
2) "Basic Straightening Methods"
3) "Using the Body Jack"
4) "Using Fillers: Lead and Plastic"
5) "Aligning Doors, Hoods and Trunk Lids"
6) "Estimating Autobody Damage"

(NOTE: This filmstrip series is available from Prentice-Hall Media; ServCode DU, 150 White Plains Road, Tarrytown, New York 10591.)

d. *Basic Auto Body Repair: Unit I*, available from Career Aids, Incorporated, 20417 Nordhoff Street, Department R, Chatsworth, California 91311; phone 818-341-8200

(NOTE: This filmstrip module includes crown recognition and checking, developing a trained eye, and developing the hand feel.)

SUGGESTED ACTIVITIES

2. Videocassettes

   a. *Dent Repair with Weld-On Washers*

   b. *Use of the Resistance Spot Welder*

   (NOTE: These two videocassettes are available from Teaching Aids, Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321.)

3. Equipment and materials for job sheet procedures

4. Vehicle or panels exhibiting each of the classes of metal damage

5. Examples of types and shapes of sheet metal used in auto-body construction

6. Transparencies and competency profiles

   (NOTE: Transparencies and competency profiles for this manual are available from the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss the skills involved and the importance of roughout in the auto-body industry.

- Discuss unit and specific objectives.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms and definitions associated with vehicle roughout.

   SUGGESTIONS:

   - Demonstrate or show students examples of appropriate terms.

   - Use Transparencies #1 and #2 to illustrate your discussion of the terms *work hardening* and *stretch*.

SUGGESTED ACTIVITIES

2. Use Information Sheet, Section II to discuss the steps in assessing auto-body metal damage.

   SUGGESTIONS:

   - Take students to an auto-body shop or use the vehicles in your facility shop and allow students to assess the damage to various vehicles. Have them write a brief summary of their assessments.
   - Show filmstrip *Basic Auto Body Repair: Unit I.*

3. Use Information Sheet, Section III to discuss the purpose of aligning detachable parts.

   SUGGESTIONS:

   - Show filmstrip "Aligning Doors, Hoods and Trunk Lids" from the series *Autobody Repair: Metal Work.*
   - Show students misaligned doors, deck lids, and hoods. Have them discuss safety hazards that could result from such misalignment.
   - Discuss further vehicle damage—such as chipped paint, bent trim, and dents—that can result from misaligned parts.
   - Show students properly aligned parts on various makes and models of vehicles.

4. Use Information Sheet, Section IV to introduce students to the basic parts of an impact-absorbing bumper.

   SUGGESTIONS:

   - Use Transparency #3 to illustrate your discussion.
   - Show students impact-absorbing bumpers on various makes and models of vehicles.
   - Provide students with copies of Supplement #1. Explain that the metal deformation system offers lower initial cost and is lighter in weight than the hydraulic system but that it is more expensive to repair because the damaged parts must be replaced after low-speed impacts. It is also less commonly used.

     Explain that impact-absorbing bumper systems usually have more parts than fixed bumper systems and are generally heavier, stronger, and more expensive than comparable parts on a fixed bumper system. However, unless the bumper is impacted at high speeds and is permanently damaged, the auto-body technician will be able to repair and replace damaged parts.

SUGGESTED ACTIVITIES

5. Use Information Sheet, Section V to stress safety rules associated with handling hydraulic energy-absorbers.

   SUGGESTIONS:

   - Review each safety rule and stress hazards that could result from improper handling.
   - Demonstrate procedures outlined in Job Sheet #12.
   - Have students complete Job Sheet #12.

6. Use Information Sheet, Section VI to discuss factors to consider when roughing out auto-body sheet metal.

   SUGGESTIONS:

   - Discuss types and shapes of sheet metal in current use and compare to auto-body metal construction of the past. Stress the increased use of aluminum and the average thickness of the sheet metal in today's automobile compared to the thickness of the sheet metal used in the past.
   - Have students compare the sheet metal used in various makes and models of foreign and domestic vehicles.
   - Use a vehicle to show students examples of the shapes of sheet metal outlined in this section.

7. Use Information Sheet, Section VII to explain the effects of bending auto-body sheet metal.

   SUGGESTION:

   - Allow students to examine with a magnifying glass a cross-section of a bent piece of sheet metal.

8. Use Information Sheet, Section VIII to discuss classes of vehicle metal damage.

   SUGGESTIONS:

   - Show students examples of each class of metal damage.
   - Use Transparency #4 to illustrate your discussion of rolled buckle.

9. Use Information Sheet, Section IX to introduce students to basic metal-straightening methods.

   SUGGESTIONS:

   - Show students examples of the tools used for each straightening method.

SUGGESTED ACTIVITIES

- Demonstrate each of the tools.
- Stress safety hazards and precautions for each of the straightening tools.

10. Use Information Sheet, Section X to introduce students to applications of the basic metal-straightening methods.

    SUGGESTIONS:

    - Show students examples of each class of metal damage and have them tell you which straightening method they would use to repair each type of damage.
    - Use Transparencies #5 and #6 to illustrate your discussion of straightening methods and their applications.

11. Use Information Sheet, Section XI to review guidelines for use and care of hydraulic rams and power jacks.

    SUGGESTIONS:

    - Stress safe working practices.
    - Demonstrate appropriate guidelines with hydraulic ram or power jack.

12. Use Information Sheet, Section XII to discuss the steps in repairing extensive metal damage.

    SUGGESTION:

    - Explain why the steps must be performed in the sequence outlined in the information sheet.

13. Use Information Sheet, Section XIII to discuss clues to determining direction of damage.

    SUGGESTIONS:

    - Explain the purpose of determining the direction of damage: damage is brought out in the reverse direction that it went in.
    - Have students examine metal damage to vehicles in your facility shop or those in a local auto-body shop so that they may practice determining the direction of damage.

14. Discuss and demonstrate procedures outlined in Job Sheets #1 through #11.

SUGGESTED ACTIVITIES

SUGGESTIONS:

- Review safety rules and procedures for setting up and using oxyacetylene welding equipment in Section A, Unit I, "Oxyacetylene Fusion Welding."
- Have students practice using a hydraulic ram and power jack before completing Job Sheet #7.
- Stress safety and accuracy, not speed of performance.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest as necessary.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Crouse, William H. and Donald L. Anglin. *Automotive Body Repair and Refinishing*. New York: McGraw-Hill Book Company/Gregg Division, 1980.

B. Duenk, Lester G., W. Randolph Williams, and Clarence A. Brooks. *Auto Body Repair*. Peoria, Illinois: Chas. A. Bennett Co., Inc. 1977.

C. *Fisher Body Service Manual '79*. Detroit, Michigan: General Motors Corporation, 1979.

D. *Fundamentals of Body Sheet Metal Repair*. Warren, Michigan: General Motors Corporation/Fisher Body Division, 1969.

E. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1974.

F. *1980 Chevrolet Chevette Shop Manual*. Detroit, Michigan: General Motors Corporation, 1979.

G. Richert, Melvin T. *How to Control Auto Body Sheet Metals*. Philadelphia: Chilton Book Company, 1968.

H. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

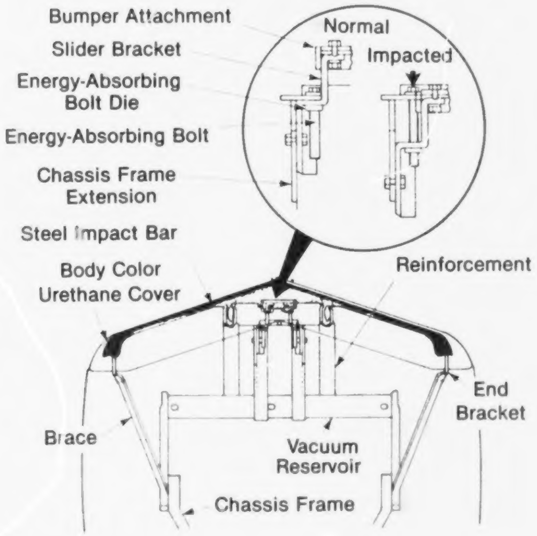
I. Spicer, Edward D. *Automotive Collision Work*, 4th ed. Chicago, Illinois: America Technical Society, 1972.

J. Tait, Alex, A. G. Deroche, and N. N. Hildebrand. *The Principles of Autobody Repairing and Repainting*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971.

SUGGESTED ACTIVITIES

SUPPLEMENT #1 — HOW IMPACT-ABSORBING BUMPER SYSTEMS WORK

System that uses metal deformation



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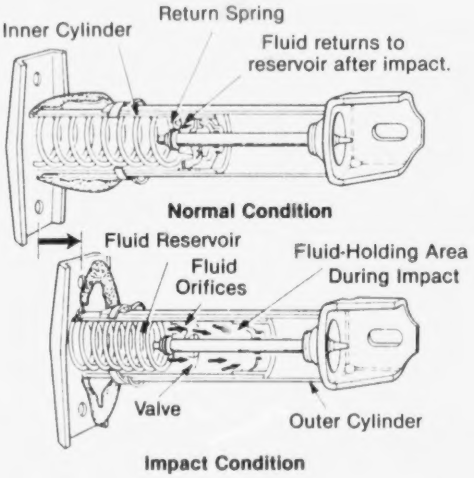
Hydraulic system



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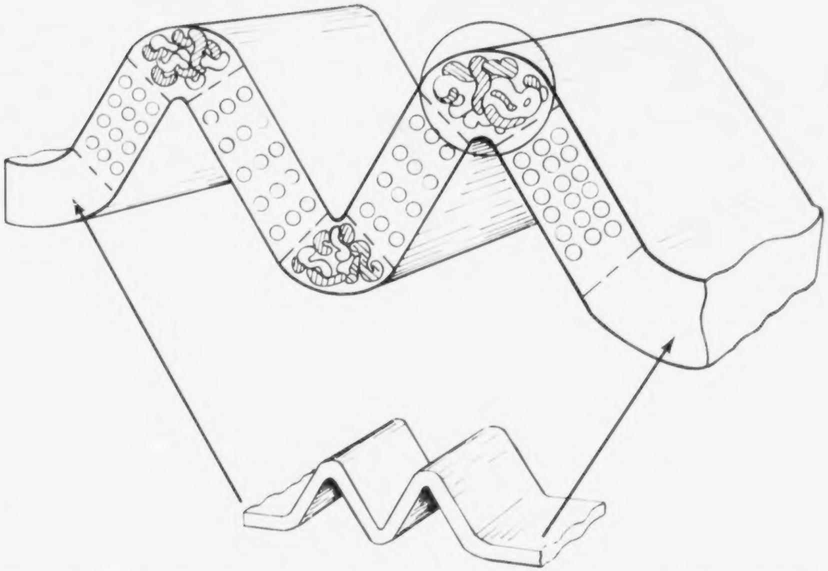
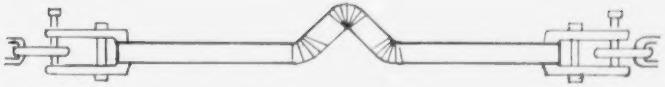
1. At impact speeds under 5 miles an hour, when impact occurs, bumper assembly is pushed back into energy absorbers
2. Hydraulic fluid in absorber cylinder is forced through orifice in piston, allowing bumper to move back slowly and absorbing blow so that it is not passed to vehicle frame
3. After impact pressure is released on bumper, return spring in inner cylinder of absorber causes bumper to return to normal position as the fluid flows back into reservoir
4. At impact speeds over 5 miles an hour, energy absorbers and other parts of vehicle are likely to be permanently damaged and body shop work is required to repair or replace damaged parts

   (NOTE: In the metal-deformation design, the urethane pad returns to its original shape with no visible evidence of the impact. However, the steel impact bar, the two energy-absorbing bolts, and the two end brackets must be replaced since they will have been permanently damaged by the impact. The metal-deformation design is not commonly used.)

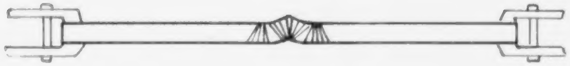
Work Hardening



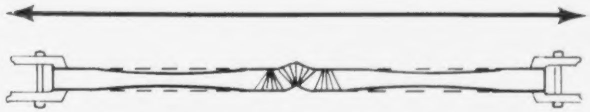
Metal when bent will cause severe locks in the bend. This process is called work hardening.



Work hardened metal will refuse



to yield by sheer pulling force.



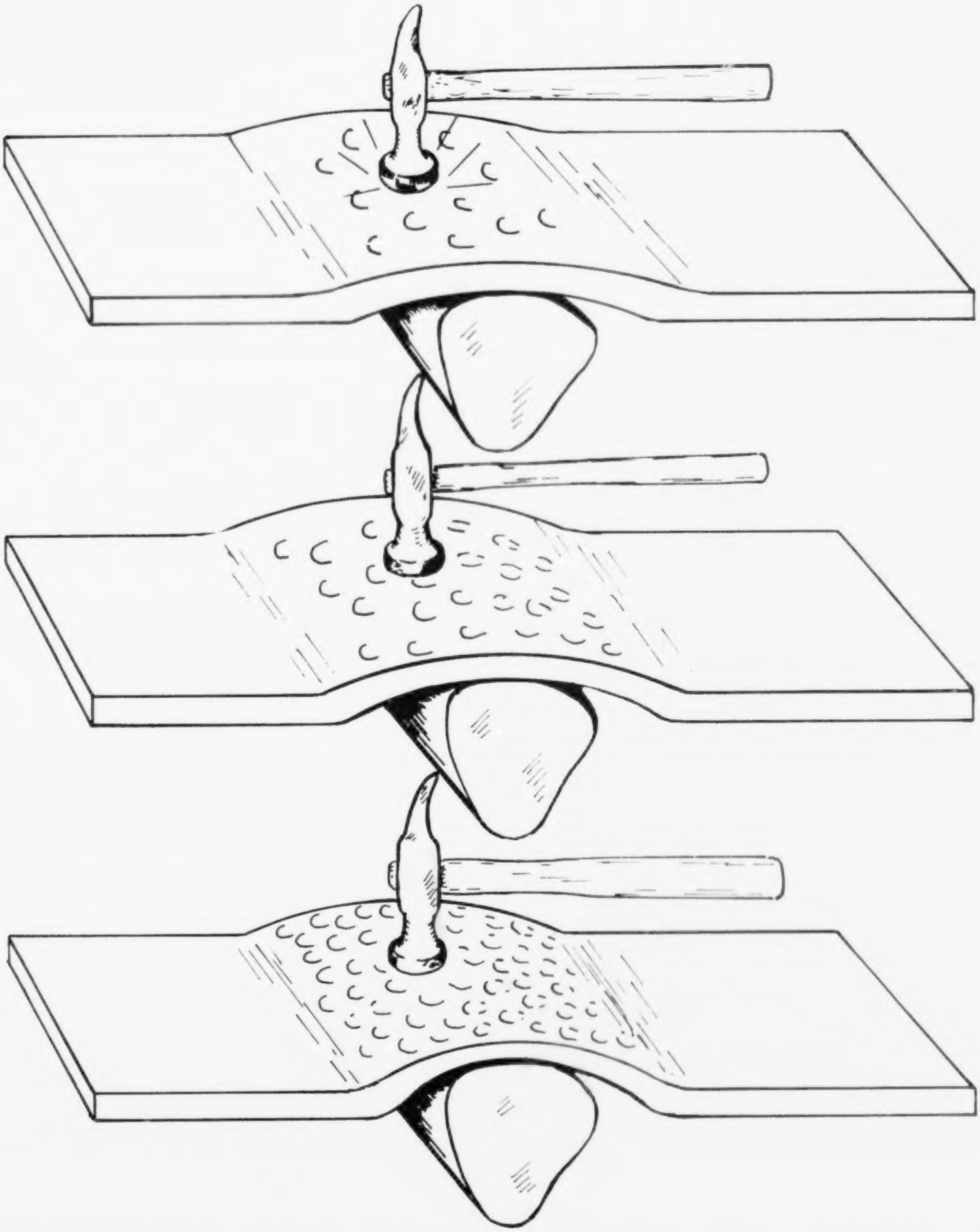
Straight portions will stretch before work hardened areas will yield.

From *How to Control Auto Body Sheet Metals* by Melvin T. Richert. Copyright 1968 by the author. Reprinted with permission of the publisher, Chilton Book Company, Radnor PA.

TM #1

ABR - 49-B

Stretch



Continuous hard hammer blows will result in stretched and severe work hardened metal.

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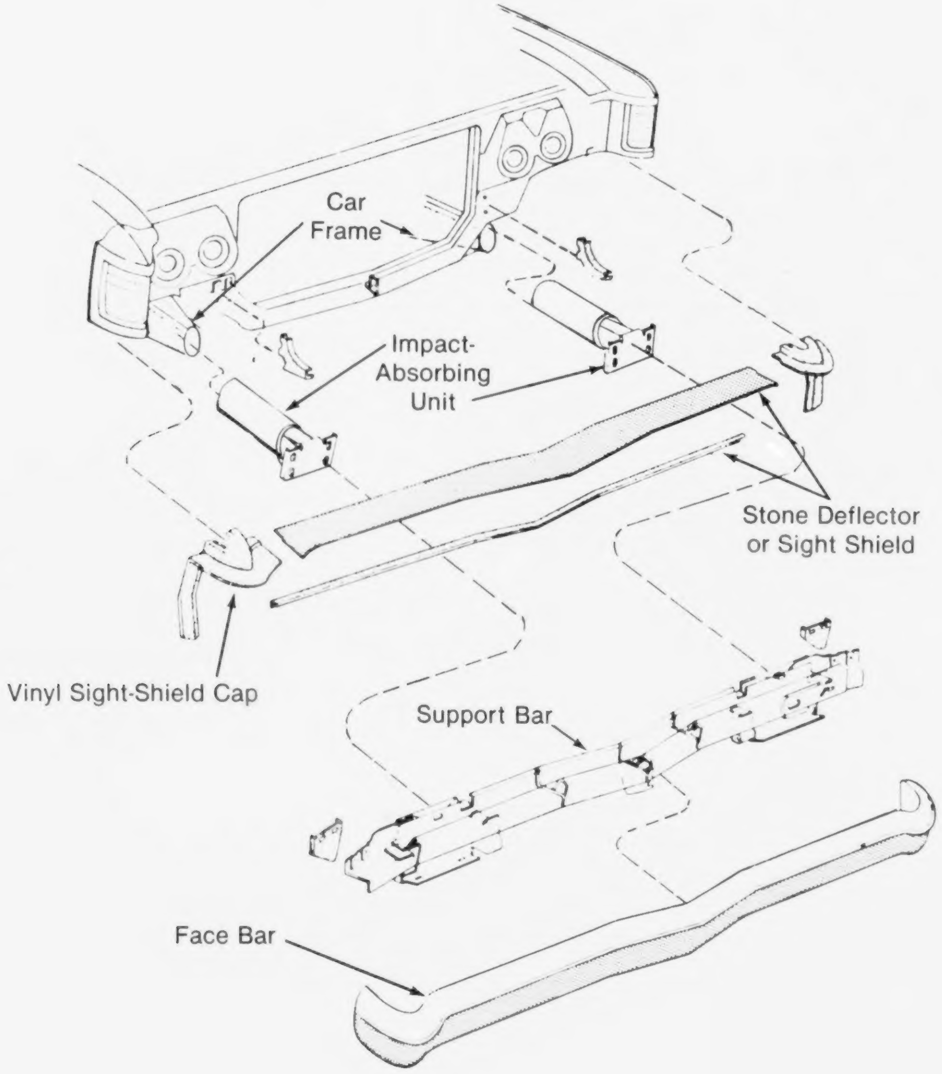
TM #2

Typical Impact-Absorbing Bumper Assembly



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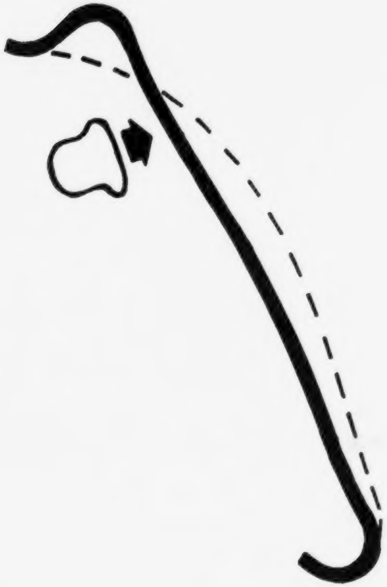
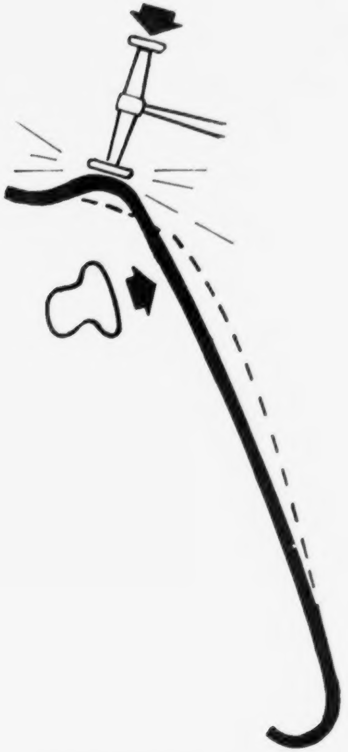
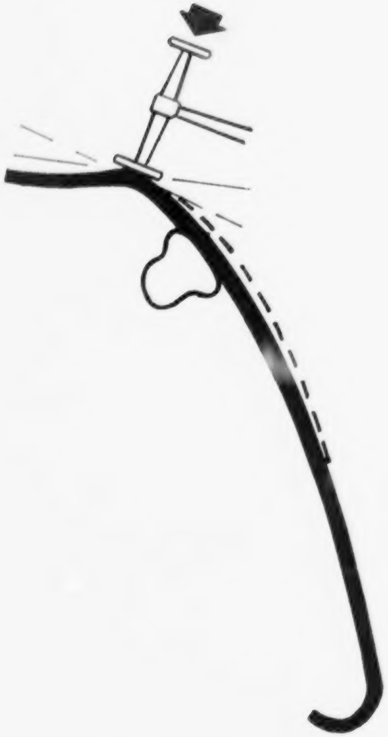
Rolled Buckle



Dolly Position for First Roughout Blow



Hammer on High Breakover Point

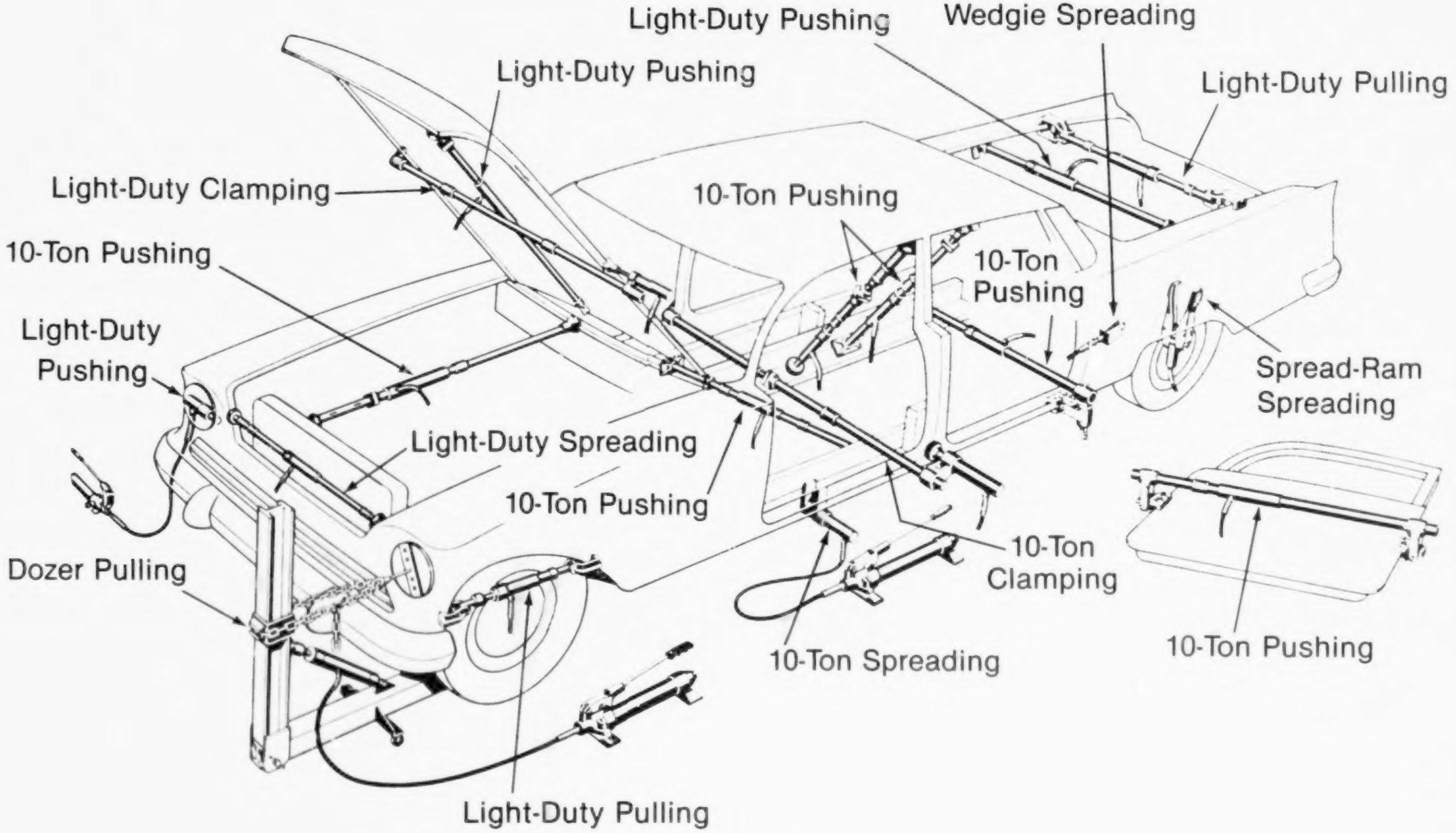


Final Buckle Condition

TM #4

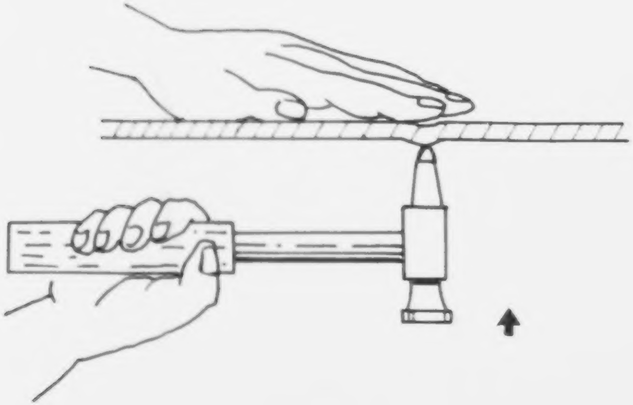
ABR - 55-B

Hydraulic Body Jack and Accessories for Basic Straightening Jobs

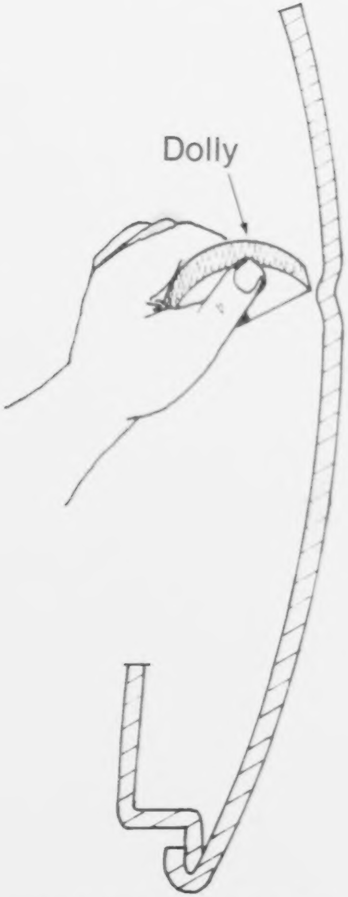


Adapted with permission of Blackhawk Applied Power, Inc., Automotive Division.

Picking



Picking is used to work out very small dents or high spots.



The dolly is used for "picking" in tight spots where a hammer will not reach.

ROUGHOUT
UNIT II

INFORMATION SHEET

I. Terms and definitions

  A. Roughout — Body repair stage in which dimensions are established and damaged panels are aligned and reshaped to proper dimensions

  B. Elastic limit — Point to which metal can be stretched and still recover

  C. Work hardening — Change of granular structure of metal by bending or forming, which causes metal to become hardened or strengthened in the bend

  D. Direct damage — Collision damage at point of impact and in immediate surrounding areas

  E. Indirect damage — Collision damage caused by impact force traveling through direct-damage area and damaging other areas of the same panel or other panels and areas

  F. Stretch — Swelling and thinning of metal due to improper hammer and dolly technique; can also result from bending and pulling

  G. Upset — Compression of metal; opposite of stretch

  H. Pressure — Pushing force or point of direct damage to body panel; metal that is pushed up

  I. Tension — Pulling force; metal that is pushed down

II. Sequence of steps in assessing auto-body damage

  A. Note extent of damage

  B. Make necessary alignment checks

  C. Classify damage and type of sheet metal

  D. Decide method of repair

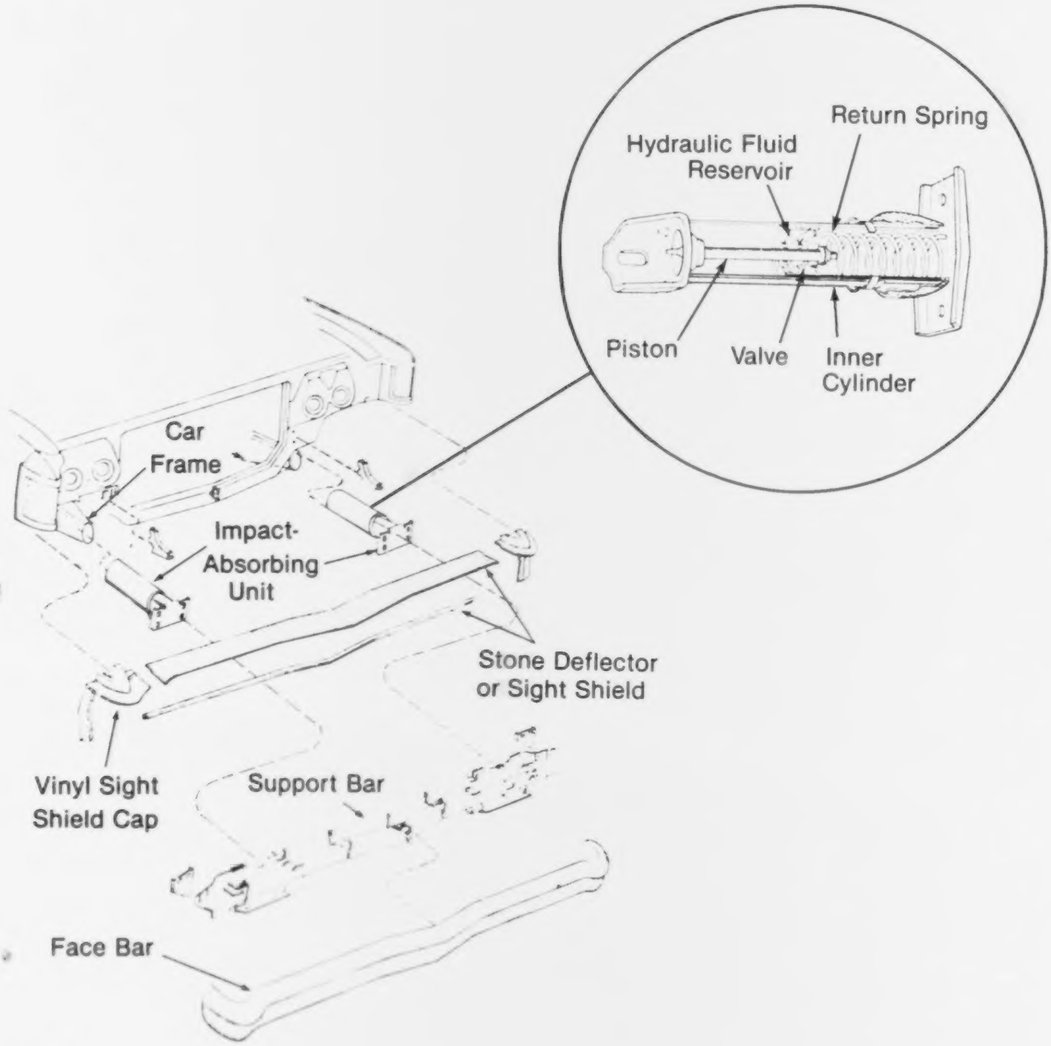
  E. Determine order of repair

III. Purpose of aligning detachable parts — To help set dimensions and proper clearances (gaps) for repair of body panels and installation of outer body panels

INFORMATION SHEET

IV. Basic parts of an impact-absorbing bumper assembly (Figure 1)

FIGURE 1



From *Total Auto Body Repair*, 2nd ed., copyright 1983. Adapted with permission of Chrysler Corporation (expanded view), and Ford Parts and Service Division, Ford Motor Company (bumper assembly).

INFORMATION SHEET

V. Safety rules to follow when handling hydraulic energy absorbers

(NOTE: When an impact absorber has been damaged in a collision, certain precautions must be taken when working on the assembly. Such precautions are necessary because the units are filled with either a gas or a liquid, which may be under considerable pressure. Impact absorbers can produce a large amount of force if they are bound up [stuck in a compressed position] and then suddenly released.)

A. Be safe; wear approved eye protection at all times

B. Stand clear of bumper at all times

C. Do not apply heat to unit

D. Do not weld in area of unit

E. Do not attempt to repair a damaged unit; always replace it with a new unit

F. When only *one* energy absorber is being replaced, support that end of bumper so that it will not fall when absorber is removed

G. If unit is bound up so that it cannot extend, attach a chain or cable to bumper to prevent it from flying forward if pressure is suddenly released

H. Relieve pressure *before* removing unit from vehicle

I. Relieve pressure *before* scrapping or disposing of a unit

VI. Factors to consider when roughing out auto-body sheet metal

A. Type

EXAMPLES: Cold rolled steel, hot rolled steel, galvanized steel, aluminum, high-strength steel (HSS); high-strength, low-alloy steel (HSLA)

B. Shape

EXAMPLES: High-crown area, low-crown area, flat panel, box section

C. Thickness (gauge)

VII. Effects of bending auto-body sheet metal (See Figure 2)

A. Outer surface becomes stretched

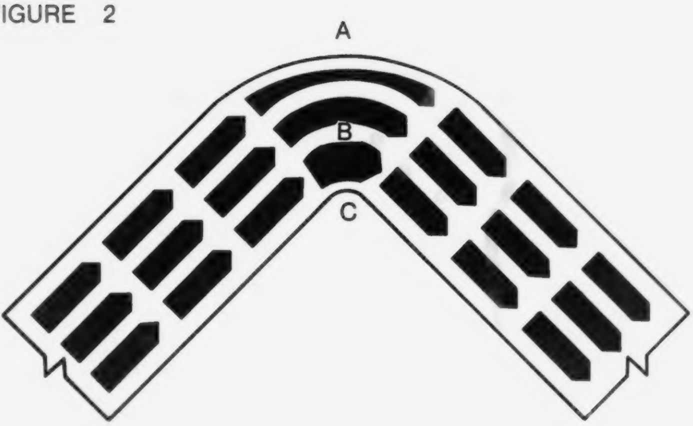
B. Center remains the same

C. Inner surface is upset (compressed and thicker)

INFORMATION SHEET

EXAMPLE:

FIGURE 2



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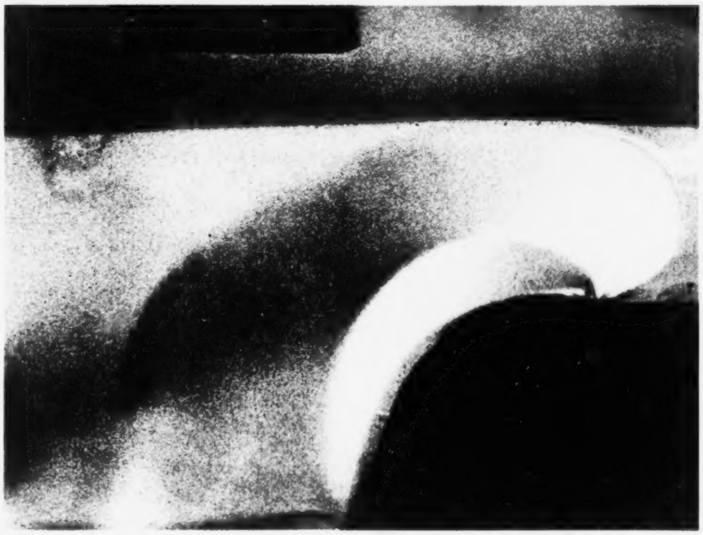
VIII. Classes of metal damage (Figures 3-10)

A. Buckle

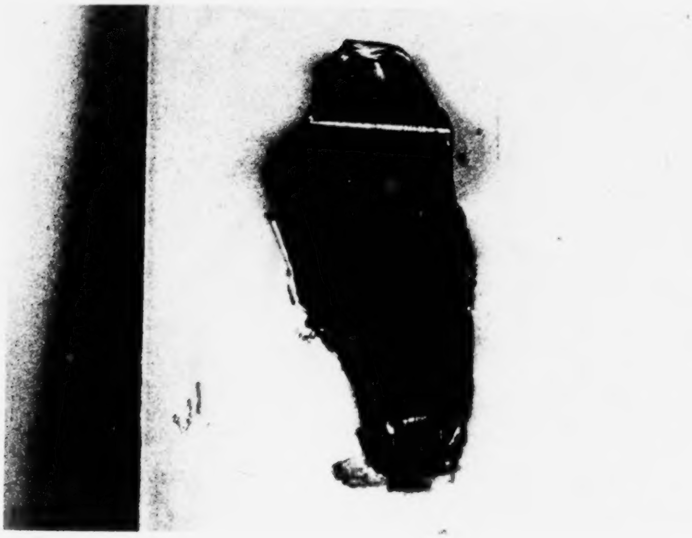
FIGURE 3



INFORMATION SHEET

B. Tear

FIGURE 4



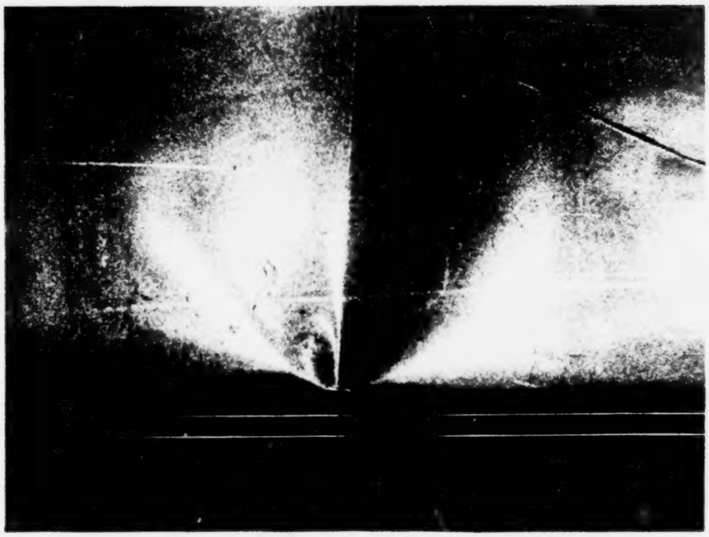
C. Gouge

FIGURE 5

INFORMATION SHEET

D. Rolled buckle

FIGURE 6



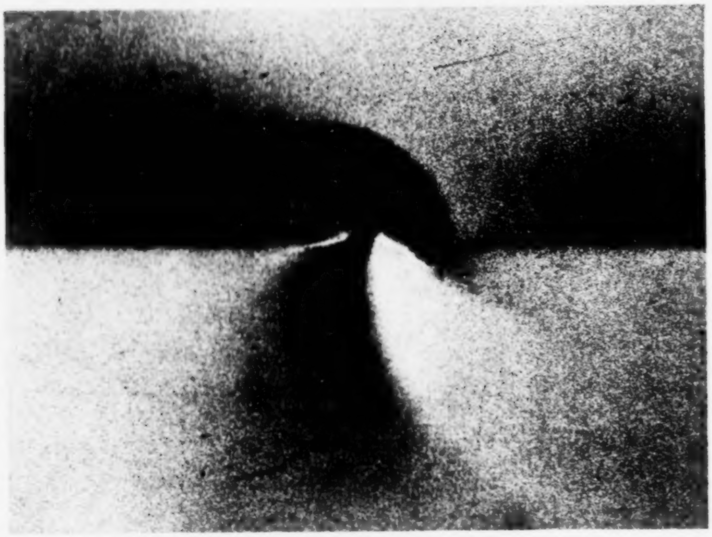
E. Eyebrow

FIGURE 7

INFORMATION SHEET

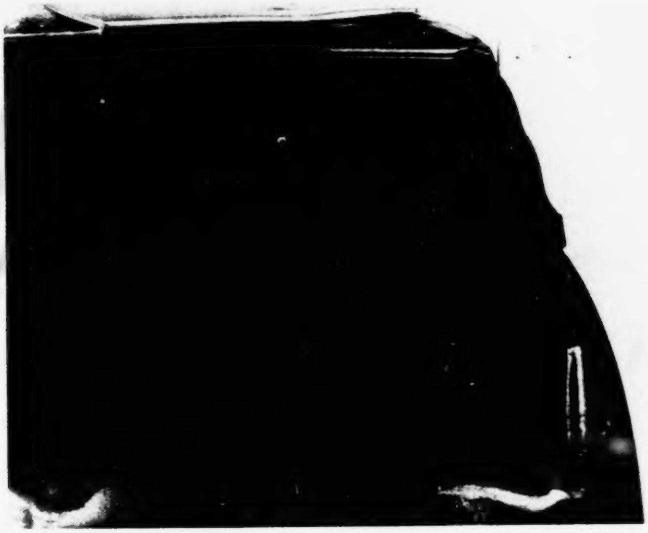
F. Hinge

FIGURE 8



G. Compression or wrinkle

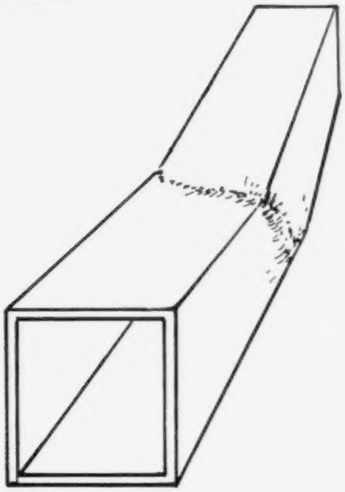
FIGURE 9



INFORMATION SHEET

H. Collapsed box section

FIGURE 10



IX. Basic metal-straightening methods (Figures 11-23)

A. Hammer and dolly

EXAMPLES:

FIGURE 11: On-dolly method

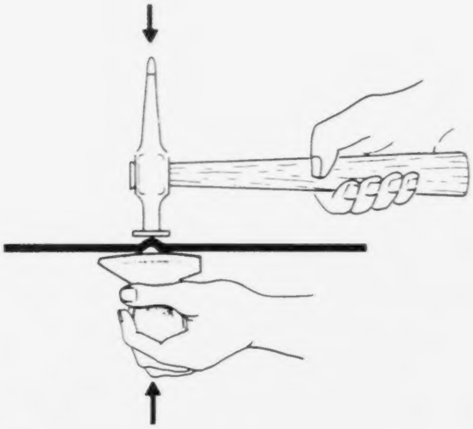
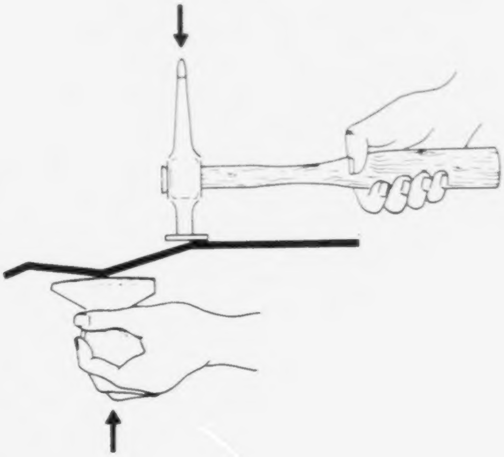


FIGURE 12: Off-dolly method



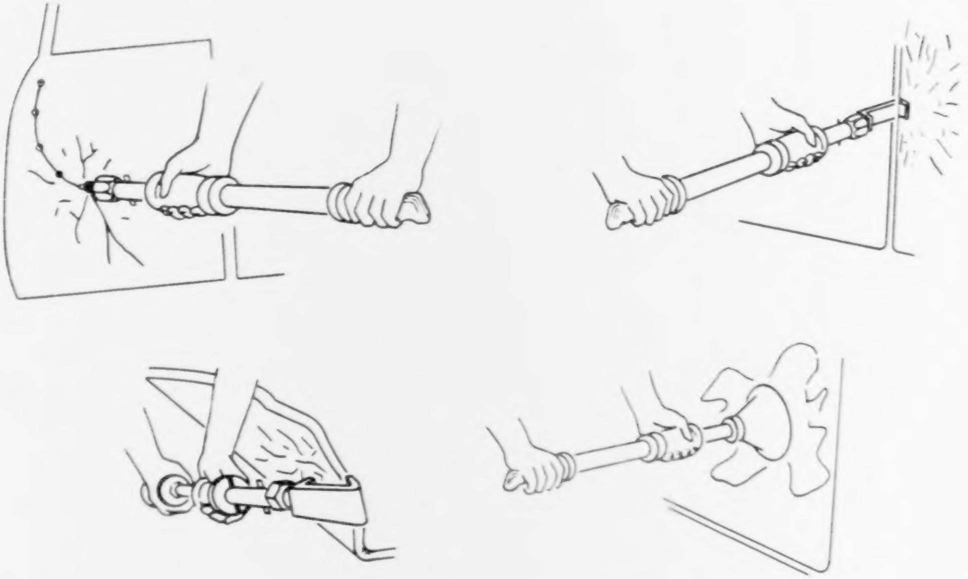
Figures 11 and 12 from *Automotive Body Repair and Refinishing*, copyright 1980. Used with permission of McGraw-Hill Book Company, Gregg Division.

INFORMATION SHEET

B. Slide hammer

EXAMPLE:

FIGURE 13

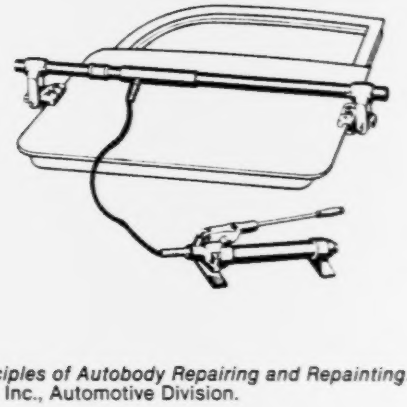


From Guy-Chart as seen in *Automotive Body Repair and Refinishing*, copyright 1980.

C. Power jack and body-pulling equipment

EXAMPLE:

FIGURE 14



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INFORMATION SHEET

D. Pull tabs and rods

EXAMPLES:

FIGURE 15: Pull Tab

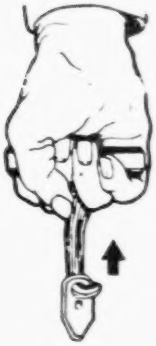

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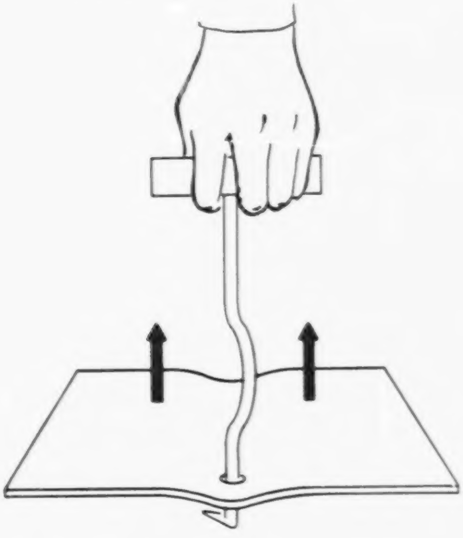
FIGURE 16: Pull Rod



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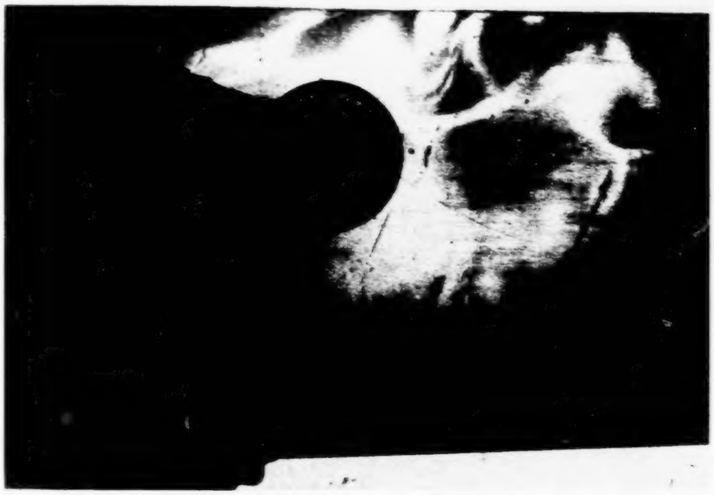
E. Vacuum cups

EXAMPLE:

FIGURE 17

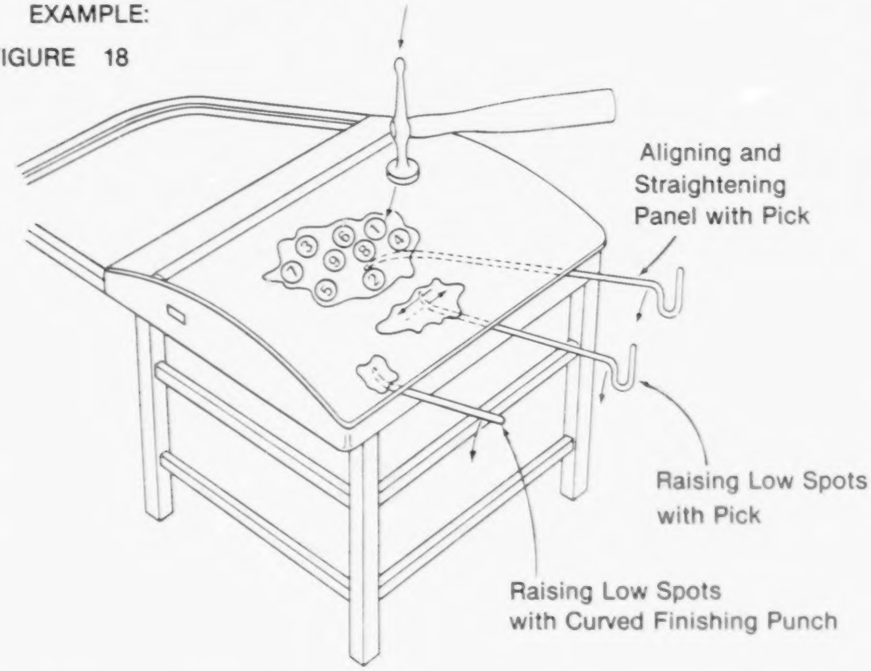


INFORMATION SHEET

F. Finishing pick (pry pick)

EXAMPLE:

FIGURE 18


Aligning and Straightening Panel with Pick
1
2
3
4
5
6
7
8
9
Raising Low Spots with Pick
Raising Low Spots with Curved Finishing Punch

Used with permission of Prentice-Hall, Inc.

G. Heat shrinking (or heating to remove work hardening)

EXAMPLES:

FIGURE 19: Heat shrinking

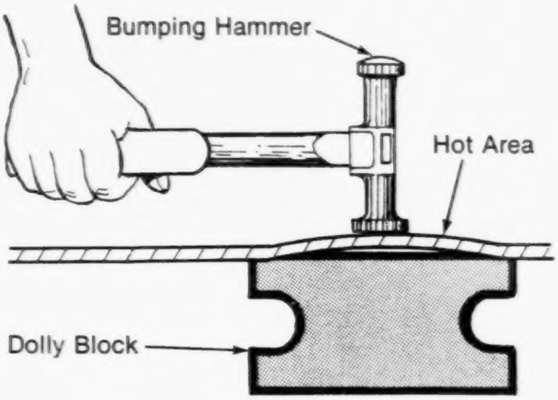
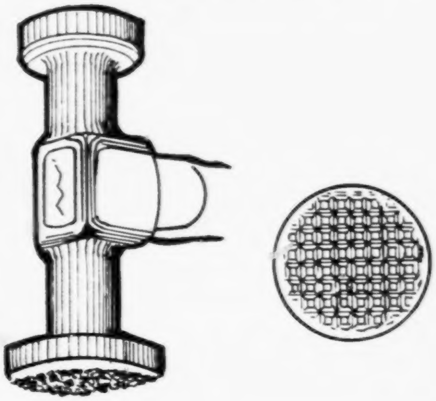


FIGURE 20: Shrinking hammer with cross-grooved face



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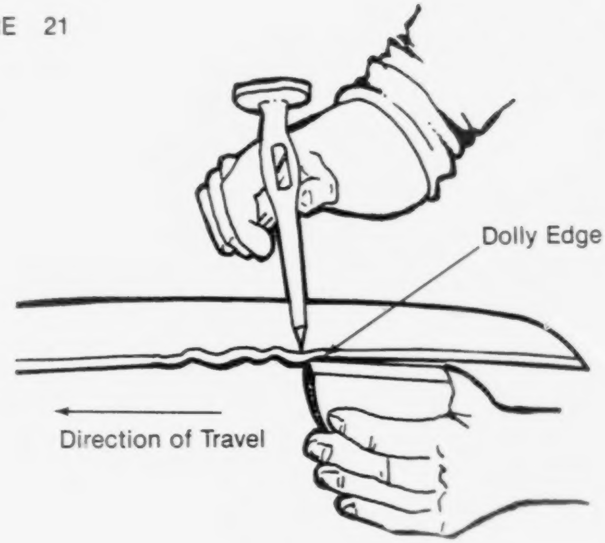
INFORMATION SHEET

H. Cold shrinking (kinking)

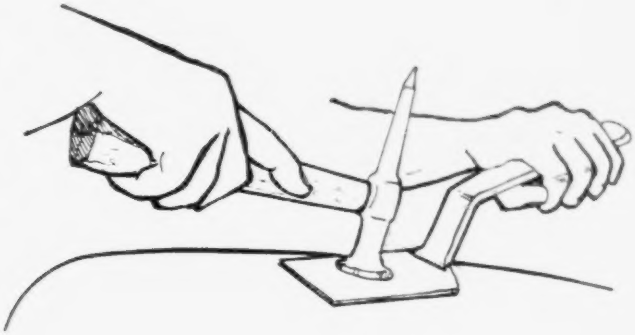
EXAMPLE:

FIGURE 21



I. Bumping spoon and hammer

FIGURE 22



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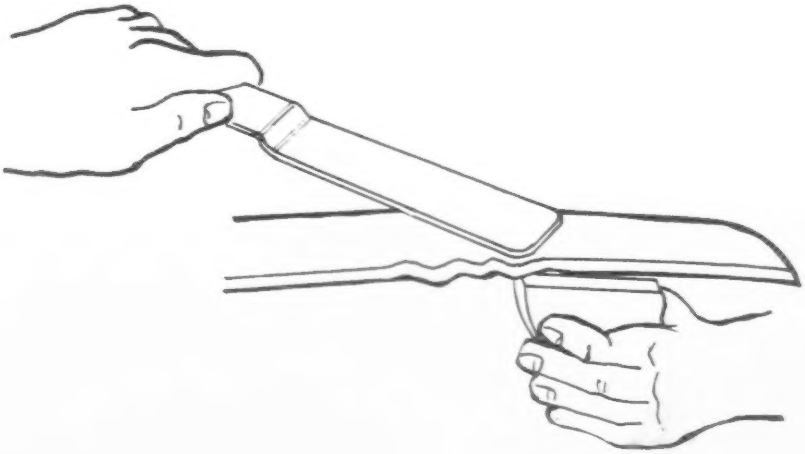
INFORMATION SHEET

J. Slapping spoon and dolly

FIGURE 23



X. Applications of basic metal-straightening methods

A. Hammer and dolly — Used for repair of metal damage that is not severe; often used on any remaining high or low spots after power jack or panel puller has been used

B. Slide hammer — Used to pull out dents and to relieve pressure around outside of metal damage that is inaccessible from behind

C. Power jack and body-pulling equipment — Used to rough out or align large wrinkled or collapsed damage by either pushing or pulling metal back to its proper shape and dimensions

D. Pull tabs and rods — Used to pull back to proper contour boxed section metal or metal inaccessible from behind

E. Vacuum cups — Used to pull out low-crown dents where there is no buckled metal

(NOTE: The metal must be clean and preferably wet.)

F. Finishing pick (pry pick) — Used to pry out metal damage that is accessible from behind

(NOTE: Pry bars or picks are especially useful in difficult-to-reach areas. Care must be taken so that metal is not pried out too far, as a stretch might occur.)

INFORMATION SHEET

G. Heat shrinking — Used to shrink metal that has stretched too far

(NOTE: Heat shrinking the metal makes it occupy the same area on the panel that it did originally. Heat shrinking is covered in further detail in Unit IV, "Shrinking.")

H. Cold-shrinking (kinking) — Used to prepare stretched metal for body filler without actually shrinking or straightening the metal

(NOTE: A pick hammer and dolly are used to kink the metal several times so that it will be lower than the rest of the panel and can be filled with body filler.)

I. Bumping spoon and hammer — Used on high-crown or eyebrow dents to return metal to its original contour without creating hammer marks

(NOTE: The flat face of the spoon does not leave dents that would cause more work in the straightening process.)

J. Slapping spoon and dolly — Used to return to its original contour shallow metal damage that is accessible from behind

XI. Guidelines for use and care of hydraulic rams and power jacks

A. Choose ram of right capacity for job

(NOTE: Overloading a ram can result in cracked cylinders, blown seals, and bent plungers.)

B. Do not overextend ram

(NOTE: Because of the tremendous hydraulic power developed by the jack pump, it is possible to push the plunger right out of the ram.)

C. Do not tamper with spring-retaining screw at bottom of ram

(NOTE: Any turning of this screw is likely to unhook the spring and thus prohibit the plunger from automatically pulling back into ram once the pressure has been released.)

D. Use the proper attachments, and protect all threads by screwing attachments on completely

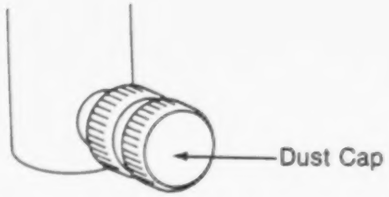
E. Keep oil lines clean at all times

INFORMATION SHEET

F. Prevent dirt and other foreign matter from entering hydraulic system by installing dust caps on coupler halves when not connected to jack pump (Figure 24)

EXAMPLE:

FIGURE 24



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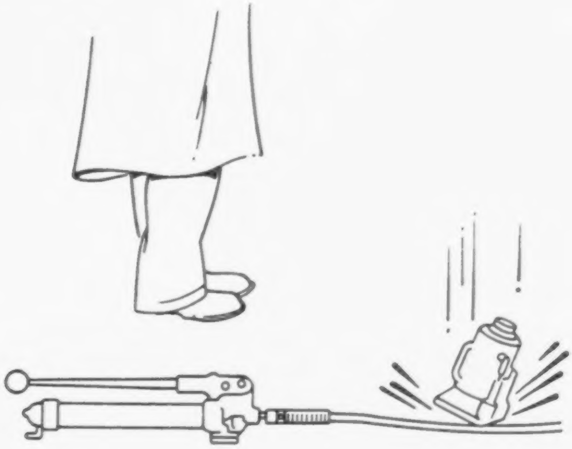
G. When using attachments where load is off center, stop frequently to adjust load to a less off-center position

EXAMPLES: Attachments such as notched pull toe, edge clamp, adjustable body spoon, or toe lift

H. Take care not to drop heavy or sharp objects on hydraulic hose as this could cause the hose to fray or kink (Figure 25)

EXAMPLE:

FIGURE 25



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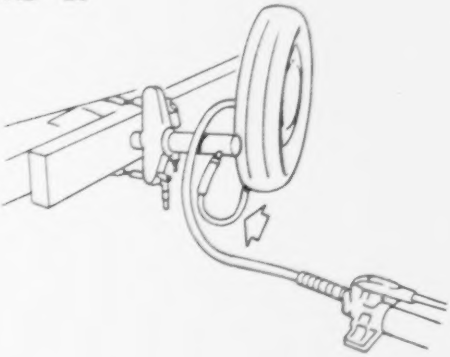
INFORMATION SHEET

I. Allow enough clearance for hydraulic hose and coupler so that no pressure will be exerted on them by the work (Figure 26)

EXAMPLE:

FIGURE 26



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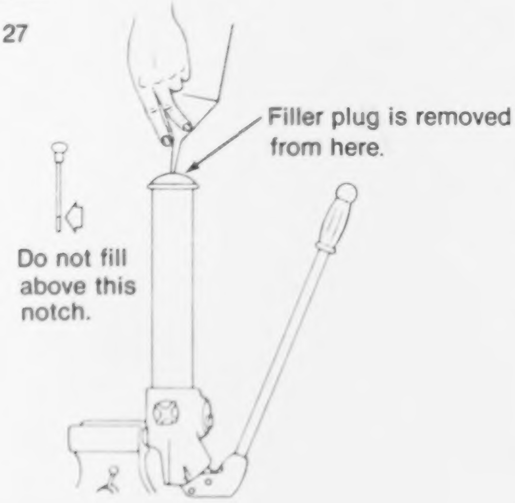
J. Avoid heating up of hydraulic equipment when using oxyacetylene torch

(NOTE: Heat will weaken and often cause damage to hydraulic hose, flexheads, and seals in ram, spreader, or wedgie.)

K. When refilling hydraulic jack with oil, first collapse ram if it is connected to jack pump, and then place pump in vice before adding hydraulic oil to proper level (Figure 27)

EXAMPLE:

FIGURE 27


Filler plug is removed from here.
Do not fill above this notch.

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INFORMATION SHEET

XII. Sequence of steps in repairing extensive metal damage

   A. Relieve pressure of direct damage in same direction and manner that it went in

   B. Relieve pressure of indirect damage, working from outer edge of damage area toward center of damaged area

   C. Rough out direct impact point

   D. Shrink if necessary

XIII. Clues to determining direction of damage

   A. Rolled buckles — Move away from point of first contact; when there are two or three, they converge (like spokes of a wheel to a hub) at point of first contact

   B. Direct damage marks — Direction of damage always ends at mark created by impact object

   C. Pressure forces — Side of greatest pressure shift of metal indicates which way the metal traveled

ROUGHOUT
UNIT II

JOB SHEET #1 — USE HAMMER AND DOLLY TO ROUGH OUT A PANEL

I. Equipment and materials

   A. Light bumping hammer

   B. Finishing hammer

   C. Appropriate dolly blocks

   D. Light body spoon

   E. Surface preparation equipment

      1. Detergent

      2. Bucket

      3. Wax and grease remover

      4. Shop towels and chamois cloths

      5. Rubber gloves

   F. Straightedge

   G. Eye protection

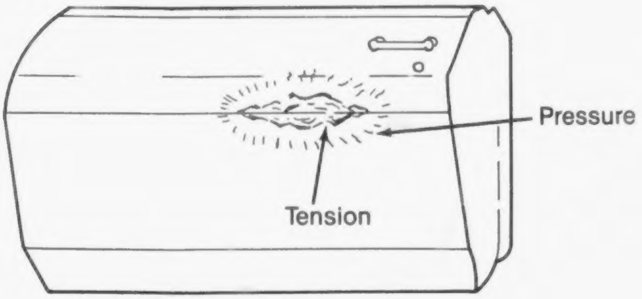
II. Procedure

(NOTE: This job sheet covers the procedure for roughing out a crease in a single-crown panel. The basic hammer and dolly procedures outlined in this job sheet may also be used to rough out other types of panels and other classes of metal damage.)

   A. Prepare damaged surface for metal repair

   B. Analyze extent and class of damage (Figure 28)

FIGURE 28: Damaged single-crown surface



JOB SHEET #1

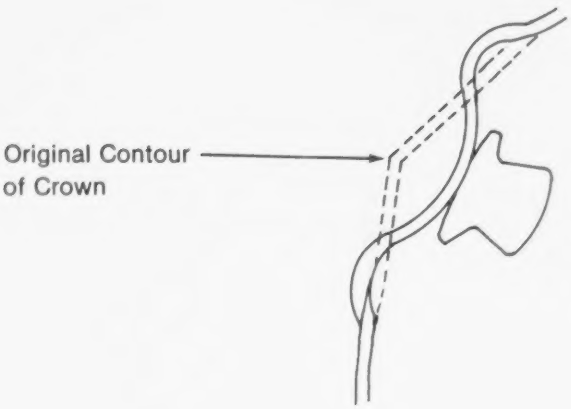
1. Determine point of impact
2. Locate direction of damage
3. Locate direct and indirect damage
4. Check internal body parts and supports for damage and accessibility
5. Establish a starting point

C. Repair damage

1. Put on eye protection
2. Select dolly appropriate to contour of panel
3. Use dolly to apply outward pressure to center of damage on crown (Figure 29)

   (NOTE: In isolated or inaccessible areas in which there is no access for the dolly, pry tools may be used to apply pressure while working strain to release crown. See Job Sheet #4.)

FIGURE 29



Side View

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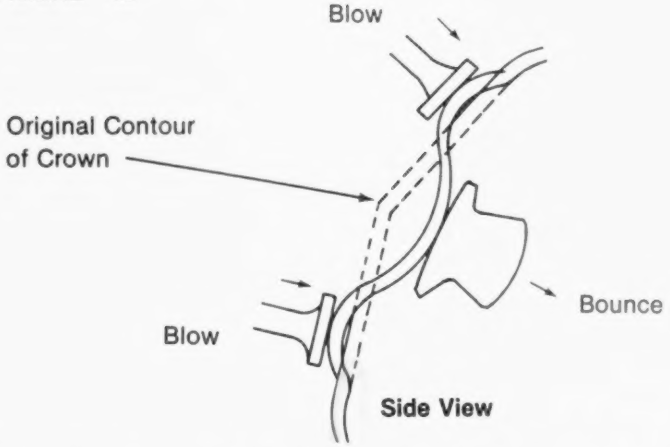
4. If light force is needed, use finishing hammer and off-dolly technique to relieve strain in pressure areas while still holding pressure on damaged crown (See Figure 30)

JOB SHEET #1

FIGURE 30



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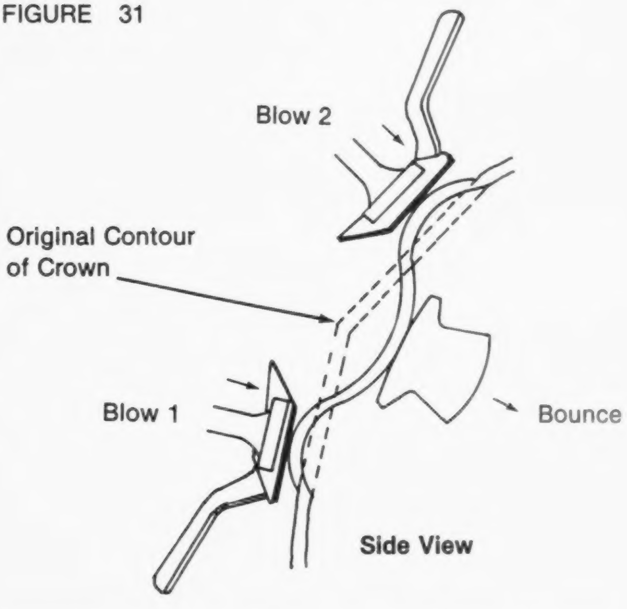
5. If heavy force is needed, use a light body spoon under bumping or finishing hammer to distribute pressure and prevent further damage to area (Figure 31)

   (NOTE: *Do not* force the metal if it resists. Review your analysis of damage and try a different technique if necessary. Too much force will stretch or work-harden the metal.)

FIGURE 31



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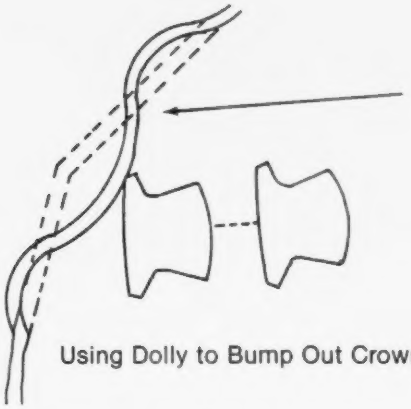
JOB SHEET #1

6. After strain is relieved, use edge of dolly to pick or bump out crown, working back and forth along entire length of damage until desired contour is obtained (Figure 32)

FIGURE 32



Using Dolly to Bump Out Crown

7. Use straightedge along crown to check accuracy of repair

8. Make further adjustments as necessary

D. Clean work area and return equipment and materials to proper storage

]

ROUGHOUT
UNIT II

JOB SHEET #2 — USE BUMPING OR SLAPPING SPOON TO ROUGH OUT A PANEL

I. Equipment and materials

  A. Bumping or slapping spoon

  B. Bumping hammer

  C. Straightedge

  D. Gloves

  E. Eye protection

  F. Surface preparation equipment

    1. Detergent

    2. Bucket

    3. Wax and grease remover

    4. Oxyacetylene equipment and full-face shield for removing undercoat if necessary

    5. Scraper

    6. Shop towels and chamois cloths

    7. Rubber gloves

II. Procedure

(NOTE: This job sheet covers the procedure for using a bumping or slapping spoon to rough out buckles in a double-crown roof panel. The bumping or slapping spoon method may also be used on other types of panels and to repair many of the other classes of metal damage.)

  A. Prepare interior and exterior surface of panel for metal repair

  B. Analyze extent of damage

    1. Check for pressure forces that might be causing the buckle

    2. Check accessibility of panel from behind

    3. Determine point of impact

    4. Locate high crown of buckle

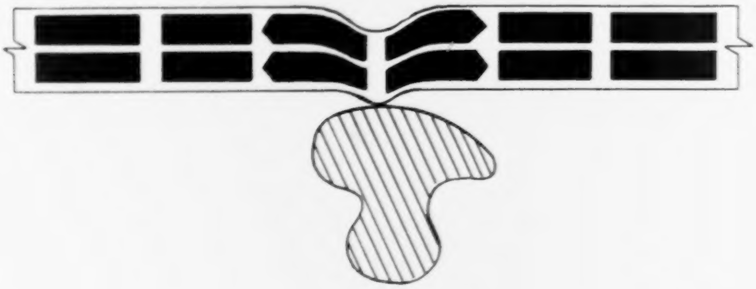
JOB SHEET #2

C. Put on eye protection

D. If damage is accessible from behind, use slapping spoon and dolly

   1. Place appropriate dolly block under center of buckle at point of impact (Figure 33)

FIGURE 33



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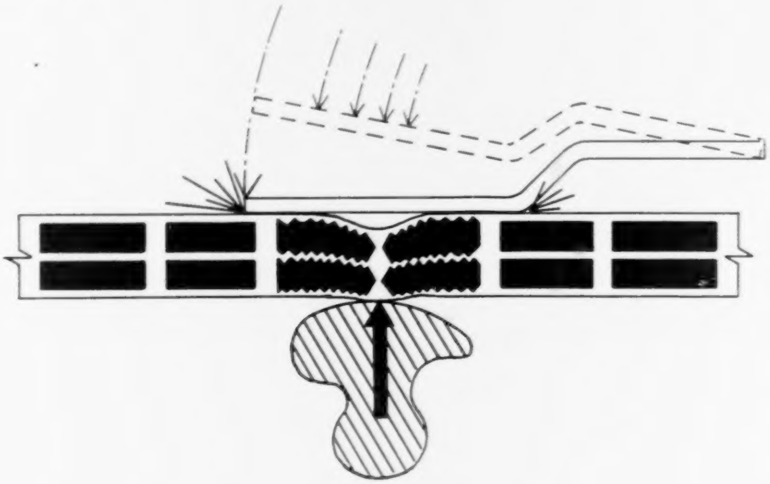
   2. Holding dolly block firmly in one hand, apply several sharp blows to exterior surface of panel over damage (Figure 34)

      (NOTE: Do not try to take all of the buckle out in just one slap.)

FIGURE 34



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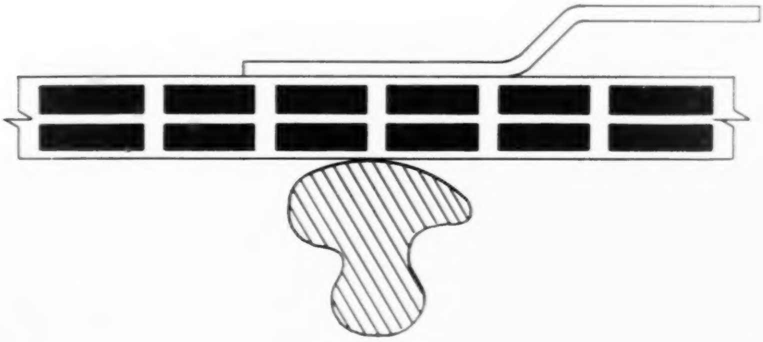
JOB SHEET #2

3. Continue this process along length of buckle until metal returns to its original contour (Figure 35)

FIGURE 35



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E. If damage is inaccessible, use bumping spoon and hammer

1. Locate edge of ridge or buckle by feeling metal with a gloved hand or with a cloth under the hand

   (NOTE: The glove or cloth helps eliminate the friction of your hand on the metal surface and makes it easier to locate the buckle.)

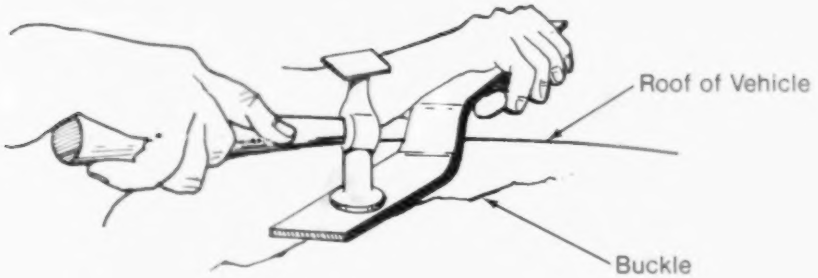
2. Place bumping spoon flat against surface of metal, starting at edge of buckle

3. Use bumping hammer and moderate force to apply several sharp blows to surface of spoon (See Figure 36)

   (NOTE: The spoon distributes the pressure to the damaged area. Do not try to take all of the buckle out in just one pass; work the buckle down slowly, trying not to dent the metal.)

JOB SHEET #2

FIGURE 36



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4. Work spoon back and forth down length of metal while applying blows with bumping hammer
5. Continue this procedure until metal returns to its original contour

F. Use straightedge to check for high or low spots that will need further work

G. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #3 — USE PULL RODS OR SLIDE HAMMER TO ROUGH OUT A PANEL

I. Equipment and materials

- A. Pull rod set
- B. 2-pound slide hammer
- C. 1/4-inch pneumatic drill
- D. 1/8-inch drill bits
- E. Light bumping hammer
- F. Finishing hammer
- G. Air compressor
- H. Straightedge
- I. Gloves
- J. Eye protection
- K. Surface preparation equipment
  - 1. Detergent
  - 2. Bucket
  - 3. Wax and grease remover
  - 4. Shop towels and chamois cloths
  - 5. Rubber gloves

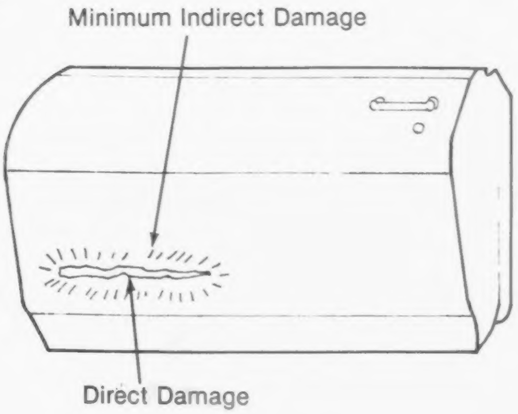
II. Procedure

(NOTE: Slide hammers and pull rods are used to rough out damage that is inaccessible from the back. They are generally used on less severe damage.)

- A. Prepare damaged surface for metal repair
- B. Analyze extent and class of damage (See Figure 37)

JOB SHEET #3

FIGURE 37



1. Determine point of impact
2. Locate direction of damage
3. Locate direct and indirect damage
4. Check internal body parts and supports for damage and accessibility
5. Establish starting point

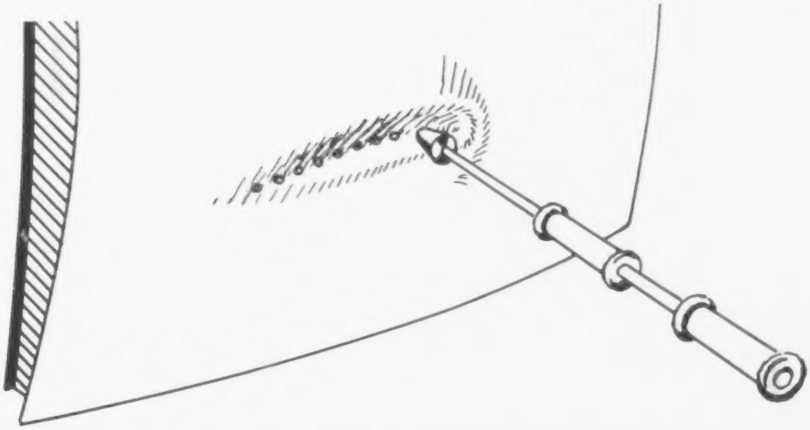
C. Repair damage

1. Put on eye protection
2. Insert drill bit into drill chuck and tighten with chuck key; remove chuck key
3. Attach compressor air hose to drill air coupler
4. Drill holes about 1/2 inch apart in damaged panel along deepest path of dent (See Figure 38)

   (NOTE: The deeper the dent, the closer the holes should be spaced.)

JOB SHEET #3

FIGURE 38



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5. Starting at one end and moving toward the other, insert tool into holes and apply outward pressure

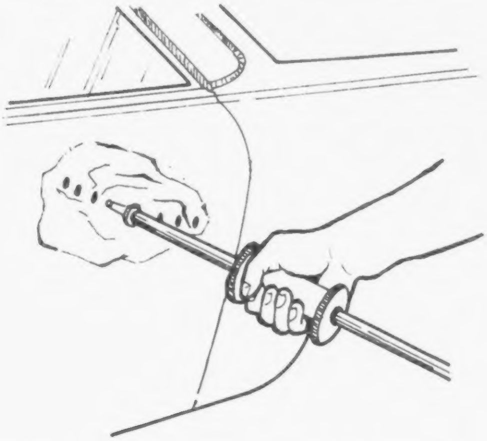
   a. If using slide hammer—

      1) Insert into hole a sheet-metal screw slightly larger than hole

      2) Turn clockwise to tighten screw

      3) Use sliding weight on hammer to apply outward pressure (Figure 39)

FIGURE 39



From Guy-Chart as seen in *Total Auto Body Repair*, 2nd ed., copyright 1983.

JOB SHEET #3

b. If using pull rods—

1) Insert pick end or ends into holes

2) Apply outward pressure to pull out dent (Figure 40)

(NOTE: If a lot of pressure is required, or if the dent is large, several pull rods may be used at one time. See Figure 41.)

FIGURE 40: Single pull rod for minimum pressure or small dent

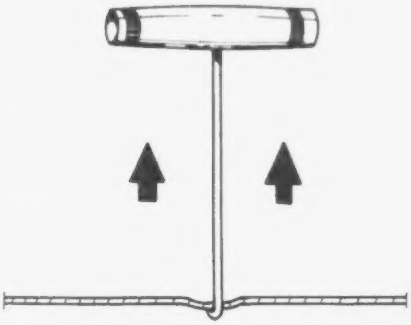
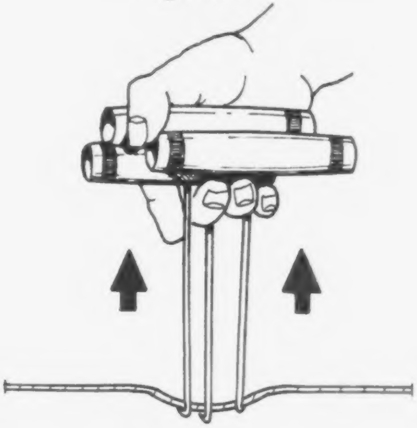
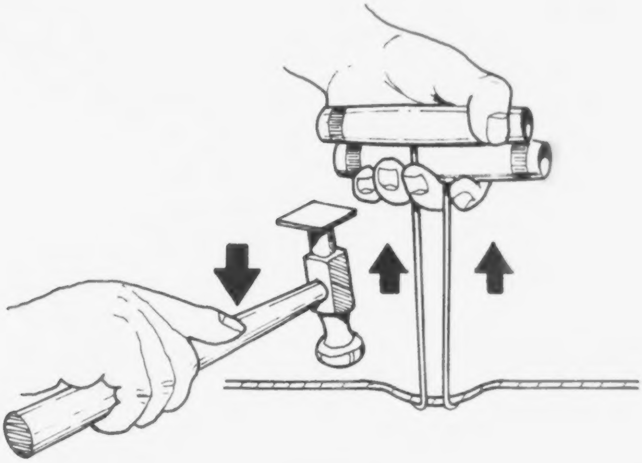


FIGURE 41: Multiple pull rods for maximum pressure or large dent



6. While raising dent with slide hammer or pull rods, relieve pressure around edge of dent with bumping hammer (See Figure 42)

FIGURE 42



JOB SHEET #3

7. Work across entire length of dent, pulling metal up a little at a time
8. Use straightedge to check panel and spot any remaining high or low areas
9. If high or low areas remain, repeat steps 5 and 6 until desired contour is obtained

D. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #4 — USE PRY PICKS OR BODY SPOON TO ROUGH OUT A PANEL

I. Equipment and materials

   A. Assorted pry picks or body spoons

   B. Bumping hammer

   C. Finishing hammer

   D. Slapping spoon

   E. Sledgehammer or electrician's hammer

   F. Portable drill motor

   G. 1/4-inch drills

   H. Center punch

   I. Eye protection

   J. Surface preparation equipment

      1. Detergent

      2. Bucket

      3. Wax and grease remover

      4. Oxyacetylene equipment and full-face shield for removing undercoating if necessary

      5. Scraper

      6. Shop towel and chamois cloths

      7. Rubber gloves

II. Procedure

   A. Prepare interior and exterior panel surfaces for metal repair

   B. Analyze extent and class of damage

      1. Determine point of impact

2. Locate direction of damage
3. Locate direct and indirect damage
4. Check internal body parts and supports for damage and accessibility
5. Establish starting point

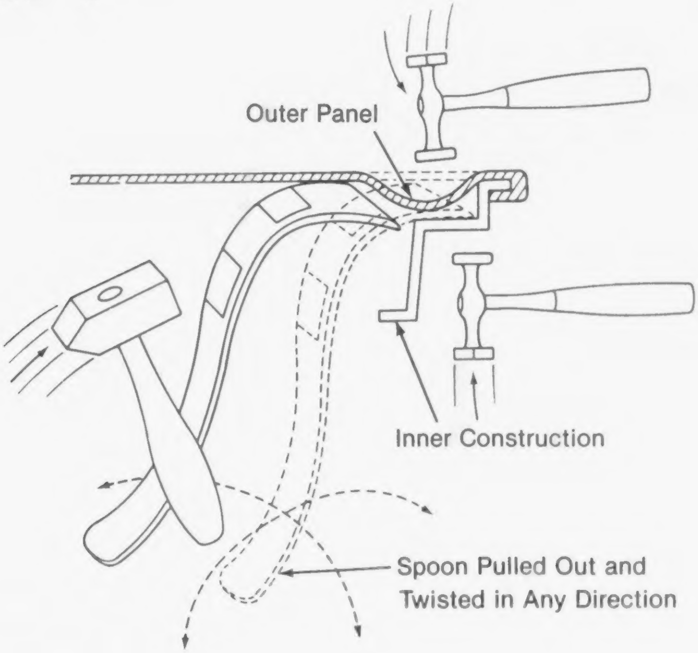
C. Check for accessibility of panel from behind, and decide which of the prying tools is best suited to reach damage

D. Put on eye protection

E. If panel is accessible from behind, use appropriate body spoon to rough out damage

1. Insert spoon at access and drive it between the two panels with an electrician's hammer or sledgehammer
2. Pry either sideways or up and down on opposite end of spoon until inner and outer panels are separated
3. Using spoon as a dolly, hammer with bumping hammer until both outer and inner panels have been straightened (Figure 43)

FIGURE 43



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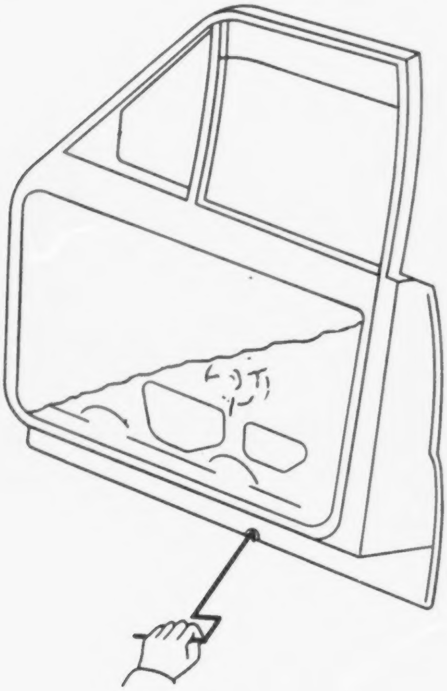
JOB SHEET #4

F. If panel is inaccessible from behind, use pry picks to rough out damage

1. Drill or punch access holes through interior supports and structures

2. Insert picking tool through access hole, and align end of tool with area to be raised (Figure 44)

FIGURE 44



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3. Apply light pressure to pry pick and watch where metal rises to determine whether you are in the right location

4. Apply pressure to pick, working around damage and moving toward center

(NOTE: Working from outer edges to center of damage relieves outer pressure and allows center of dent to rise back up slowly.)

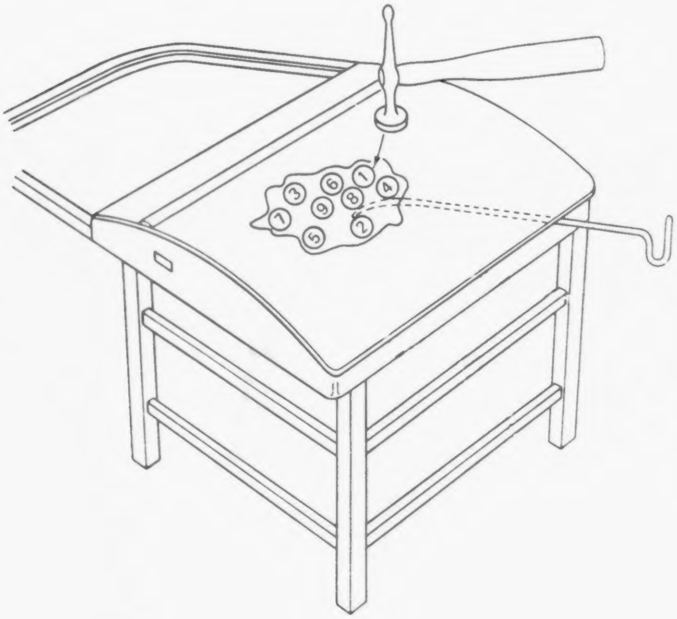
CAUTION

Take care not to exert so much pressure that you pry out metal too far, as this may stretch the metal and require more work to repair.

JOB SHEET #4

5. While the metal is raised to desired level, use bumping hammer to relieve pressure or buckles in area of damage (Figure 45)

FIGURE 45



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6. When metal has been returned to its original contour, remove pry picks from panel

G. Use straightedge to check work for any remaining high or low spots

H. Clean work area and return equipment and materials to proper storage

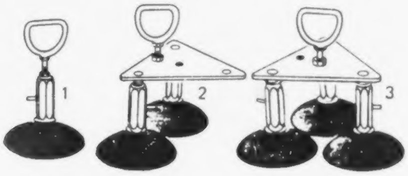
ROUGHOUT
UNIT II

JOB SHEET #5 — USE VACUUM CUPS TO ROUGH OUT A PANEL

I. Equipment and materials

A. Vacuum cup or cups (Figure 46)

FIGURE 46



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B. Finishing hammer

C. Slapping spoon

D. Straightedge

E. Eye protection

F. Surface preparation equipment

1. Detergent
2. Bucket
3. Wax and grease remover
4. Shop towels and chamois cloths
5. Rubber gloves

II. Procedure

(NOTE: This job sheet covers the procedures for using vacuum cups to rough out shallow damage in a low-crown door panel. The vacuum cup method may also be used on other low-crown panels as long as the surface is smooth and the damage is shallow.)

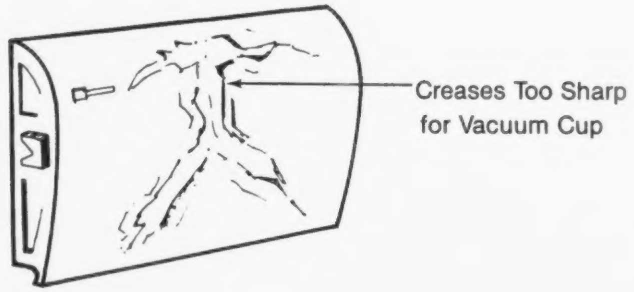
A. Prepare damaged surface for metal repair

JOB SHEET #5

B. Analyze extent and class of damage

1. Check damaged area to make sure that there are no creases or buckles that would prevent suction pressure (Figure 47)

FIGURE 47



2. Determine point of impact
3. Locate direction of damage
4. Locate direct and indirect damage
5. Check internal panels and body supports
6. Establish a starting point

C. Repair damage

1. Wet damaged area with water

   (NOTE: If possible, the surface should have paint on it and should not be sanded or roughed up.)

2. Wet surface of suction cup or cups with water
3. Attach suction cup or cups directly over damage by pressing on cup to force out air and make a vacuum seal

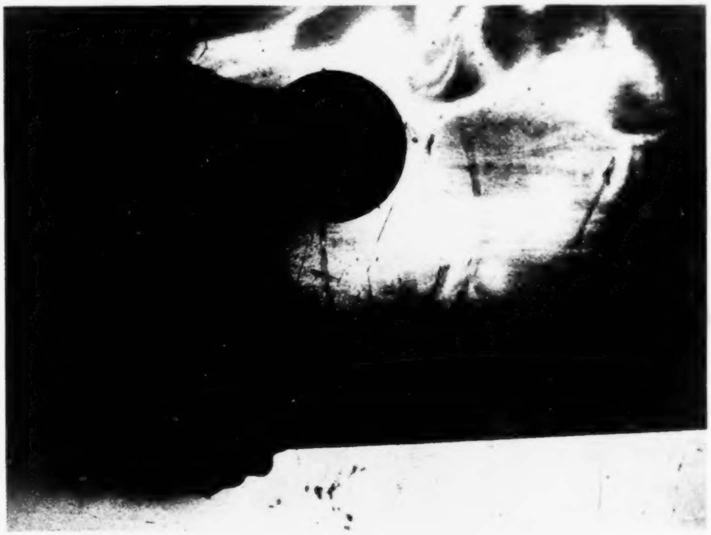
   (NOTE: Try to center the cup over the center of the damage, so that you can bring the damage out as it went in.)

JOB SHEET #5

4. Slowly pull outward on vacuum cup, relieving any stress or buckles by hammering lightly on stressed or buckled area with finishing hammer or slapping spoon (Figure 48)

   (NOTE: If the dent is large, more than one area may have to be pulled.)

FIGURE 48



5. When metal has returned to its original contour, release suction cup pressure by pulling trigger
6. Smooth any remaining buckles in door with finishing hammer or slapping spoon
7. Use straightedge to check panel and spot any remaining high or low spots

D. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #6 — USE PULL TABS TO ROUGH OUT A PANEL

I. Equipment and materials

- A. Resistance spot welder and instruction manual
- B. Pull tabs
- C. Pull hook
- D. Pull plate
- E. Welder tips
- F. Bumping hammer
- G. Portable body grinder
- H. Appropriate grinding discs
- I. Straightedge
- J. Slide hammer
- K. Eye protection
- L. Gloves
- M. Surface preparation equipment
    1. Detergent
    2. Bucket
    3. Wax and grease remover
    4. Oxyacetylene equipment and full-face shield for removing undercoating if necessary
    5. Scraper
    6. Shop towels and chamois cloths
    7. Rubber gloves

JOB SHEET #6

II. Procedure

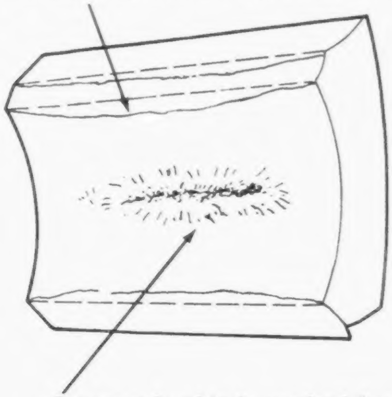
(NOTE: This job sheet covers the procedure for using pull tabs to rough out a reverse-crown panel having a sharp crease. However, the pull-tab method may also be used on other types of panels to pull out many of the other classes of metal damage.)

A. Prepare damaged surface for metal repair

B. Analyze extent and class of damage (Figure 49)

FIGURE 49

Metal on sides of reverse crown is pulled toward point of impact.



Concave buckle is pushed forward on impact.

1. Determine point of impact
2. Locate direction of damage
3. Locate direct and indirect damage
4. Check internal body parts and supports
5. Establish starting point

C. Repair damage

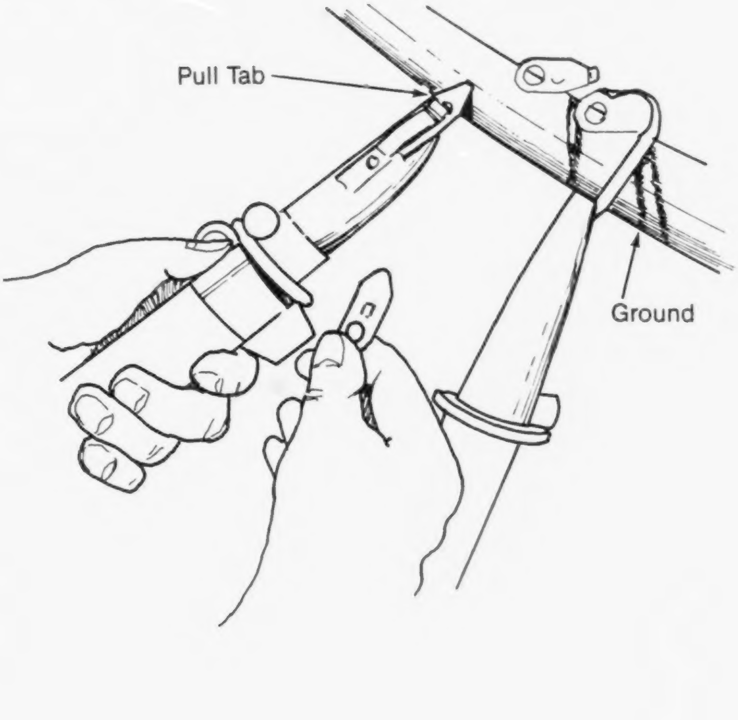
1. Put on eye protection
2. Install appropriate grinding disc on grinder
3. Connect grinder to power source and turn on

JOB SHEET #6

4. Grind paint off edge of crease down length of damage in a ½-inch wide strip
5. Turn off grinder and disconnect from power source
6. Set up welding equipment
7. Place tab in welding tip and set welder to heat range recommended by manufacturer
8. While holding ground against metal surface, weld first tab to one end of crease
9. Attach ground lead to welded tab (See Figure 50)
10. Weld remaining tabs in place at approximately 1-inch intervals (Figure 50)

    (NOTE: The distance between the tabs will vary depending on the extent and severity of the damage. Generally, the deeper the damage, the closer the tabs.)

FIGURE 50



JOB SHEET #6

11. Turn off and disconnect welder

12. Apply outward pressure to pull tabs, using the most appropriate of the following two methods

    a. Pull-hook method

        1) Attach pull hooks to holes in tabs

        2) Apply outward pressure to pull hooks while using bumping hammer to help relieve stress around damage

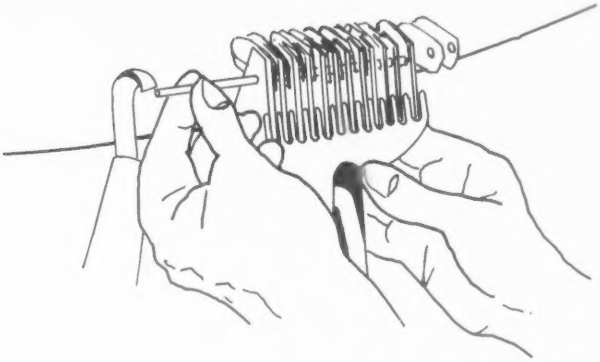
        3) Continue hammering and applying pressure until metal has returned to its normal contour

    b. Slide hammer and pull-plate method

        1) Thread rod through holes in pull tabs

        2) Attach tab puller to rod (Figure 51)

FIGURE 51

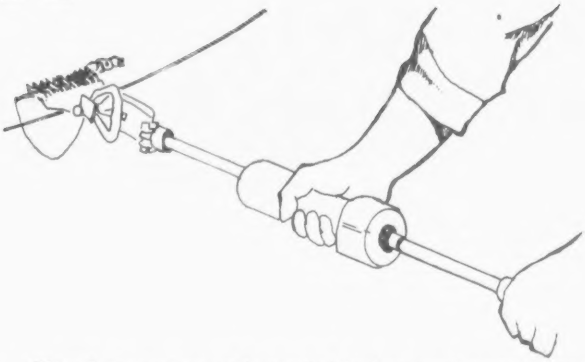


        3) Attach slide hammer to tab puller

        4) Use sliding weight on slide hammer to pull damaged metal back to its normal contour (See Figure 52)

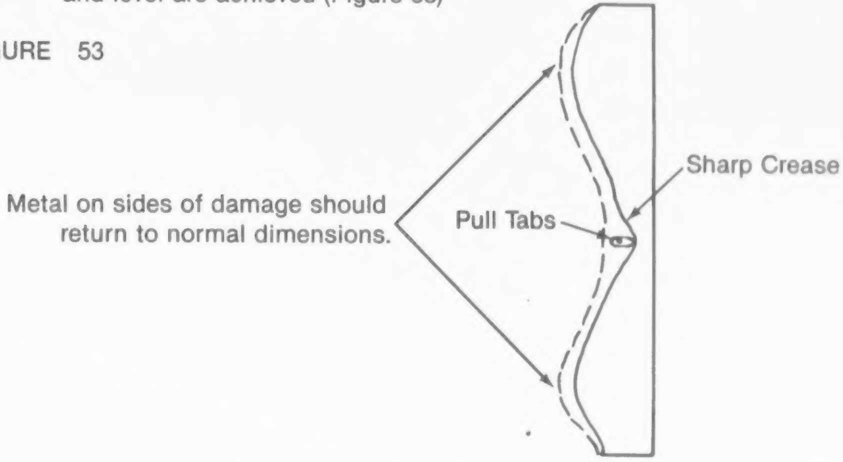
JOB SHEET #6

FIGURE 52



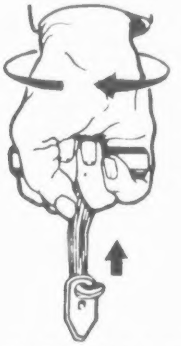
13. Check progress with straightedge, and continue pulling until proper shape and level are achieved (Figure 53)

FIGURE 53


Metal on sides of damage should return to normal dimensions.
Pull Tabs
Sharp Crease

14. Remove tabs by twisting with pull hook or by twisting back and forth until bond is broken (Figure 54)

FIGURE 54



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JOB SHEET #6

15. Install appropriate grinding disc on grinder

16. Connect grinder to power source and turn on

17. Grind out roughness left from welding tabs to metal; use proper techniques and grind rough spots level with surface

18. Turn off grinder and disconnect from power source

D. Clean work area and return equipment and materials to proper storage

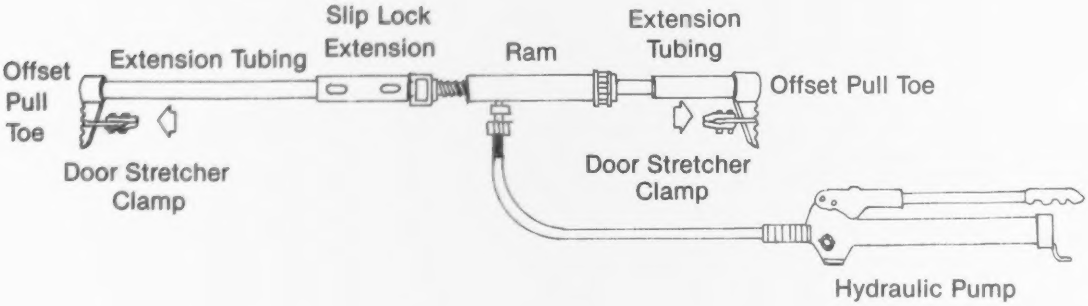
ROUGHOUT
UNIT II

JOB SHEET #7 — USE HYDRAULIC RAM AND POWER JACK TO ROUGH OUT A PANEL

I. Equipment and materials

A. Hydraulic power jack set (Figure 55)

FIGURE 55



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B. Floor jack

C. Assorted body hammers

D. Assorted dolly blocks

E. Combination-end wrench

F. 3/8-inch drive socket set

G. Door-hinge wrench

H. Ball-peen hammer

I. Center punch

J. Straightedge

K. Steel tape

L. Eye protection

M. Surface preparation equipment

JOB SHEET #7

1. Detergent
2. Bucket
3. Wax and grease remover
4. Shop towels and chamois cloths
5. Rubber gloves

II. Procedure

(NOTE: This job sheet covers the procedure for using a power jack to stretch a door panel. However, the power jack can be used for nearly all jobs in auto-body repairing. The power jack and various accessories can be used for pushing, pulling, clamping, and spreading the stronger reinforced sheet-metal sections and assemblies on auto bodies and for minor repairs on frames.)

A. Put on eye protection

B. Remove damaged door from vehicle

  1. If hinge is bolted on—
    a. Open door and support with floor jack
    b. Scribe around outside of hinges with center punch
    c. Use door-hinge wrench, socket set, or combination-end wrench to remove retaining bolts from lower hinge and then from upper hinge
    d. Set bolts aside or place in a container so that they will not get lost or damaged
  2. If hinge is welded on—
    a. Open door and support with floor jack
    b. Remove lower door-hinge pin with center punch and ball-peen hammer and then remove upper door-hinge pin
    c. Set hinge pins aside or place in container so that they will not get lost or damaged

C. Remove any door accessories, such as a side mirror, that would interfere with the repair process

D. Prepare damaged surface for metal repair

E. Analyze extent and class of damage

JOB SHEET #7

1. Determine point of impact
2. Locate direction of damage
3. Locate direct and indirect damage
4. Check internal body parts and supports
5. Establish a starting point

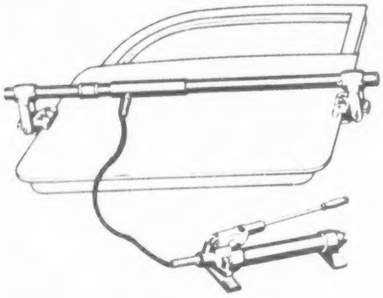
F. Repair damage

1. Select ram of correct capacity for extent and class of damage
2. Lay door face up on a flat surface, and use combination-end wrench to attach one door stretcher clamp to undamaged edge of door
3. Attach second door stretcher clamp to damaged edge of door opposite first clamp and at deepest part of damage

   (NOTE: You may have to use hammer and dolly technique to provide a flat surface to anchor second clamp.)
4. Attach ram and extension tubing to clamps
5. Attach power jack to ram-and-clamp assembly (Figure 56)

   (NOTE: An alternate method of setting up the ram and power jack equipment is to attach first clamp to door edge and then attach extension and ram to that clamp before attaching second clamp.)

FIGURE 56



From *The Principles of Autobody Repairing and Repainting.* Adapted with permission of Blackhawk Applied Power, Inc., Automotive Division.

JOB SHEET #7

6. Apply pressure *slowly*, allowing damage to work its way out gradually

> **CAUTION**
>
> Obey all safety rules for hydraulic jack and ram. Discontinue pressure as soon as damage has worked its way out.

7. As damage moves back into place, use proper hammer and dolly techniques to return metal to its proper contour

8. After movement has stopped, measure door and compare this measurement to that of undamaged door

9. Once proper dimensions and contour have been obtained, relieve pressure from jacking equipment by turning pressure relief valve at bottom of jack pump counterclockwise

10. Remove jack from ram and ram from stretcher clamps

11. Install dust caps on coupler halves of ram and jack

    (NOTE: The vehicle is now ready for further metal straightening and finishing procedures. When these have been completed, the door accessories and trim will be reinstalled and the door will be reinstalled on the vehicle.)

G. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #8 — ALIGN A HOOD

I. Equipment and materials

   A. Combination-end wrenches (standard or metric)

   B. 3/8-inch drive socket set

   C. Body shims of assorted thicknesses

   D. Scratch awl

   E. Steel tape

   F. Straightedge

   G. Eye protection

   H. Lubricating oil

II. Procedure

   A. Work hinges up and down to see that they move freely; lubricate hinges if necessary

   B. Replace any worn or damaged hinges

   C. Lower hood and check clearance along cowl (Figure 57)

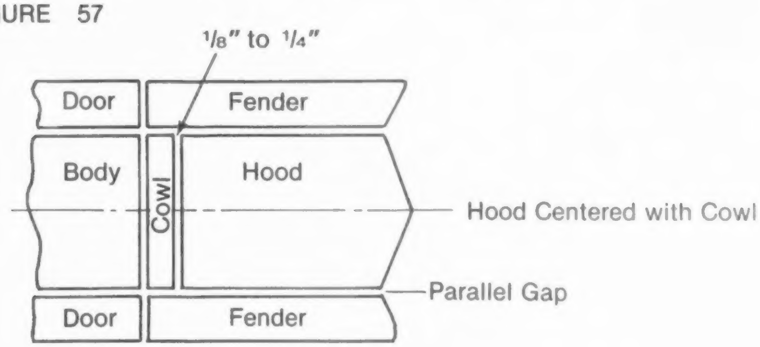
   (NOTE: Some vehicles are built without a cowl panel. On these vehicles, clearance should be checked on fenders and header panel only.)

      1. Hood should be aligned with cowl on both left and right sides

      2. Hinged end of hood should be level with cowl

      3. There should be proper clearance (1/8 to 1/4 inch) between hood and cowl, with tolerance of 3/16 inch plus or minus 1/16 inch

FIGURE 57



JOB SHEET #8

D. Put on eye protection

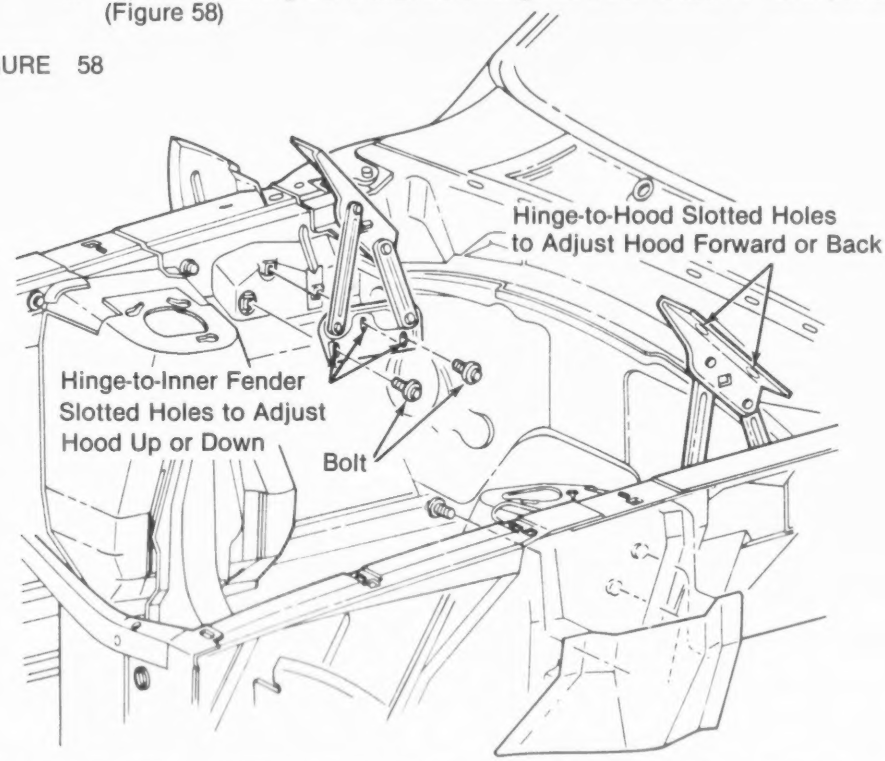
E. Use one of the following methods to adjust hood to proper height with cowl

1. Adjust hood by moving hinges

    a. Use scratch awl to scribe location of bolts through hinge at hood and at inner fender of cowl panel

    b. Loosen retaining bolts that hold hinge to inner fender or cowl panel (Figure 58)

FIGURE 58


Hinge-to-Hood Slotted Holes to Adjust Hood Forward or Back
Hinge-to-Inner Fender Slotted Holes to Adjust Hood Up or Down
Bolt

From *Total Auto Body Repair*, 2nd ed., copyright 1983. Used with permission of Ford Parts and Service Division, Ford Motor Company.

c. Wiggle hinge up and down to assure that movement can take place

d. Place hinge in desired location, noting original scribed location of retaining bolts

e. Tighten retaining bolts

f. Close hood slowly and check for proper height at cowl

CAUTION

Avoid chipping the paint with the misaligned hood during the aligning and adjusting process.

JOB SHEET #8

   g. If hood does not align with height of cowl, repeat process until desired height is obtained

2. Adjust hood by using shims

   a. Use scratch awl to scribe original location of bolts on upper hinge

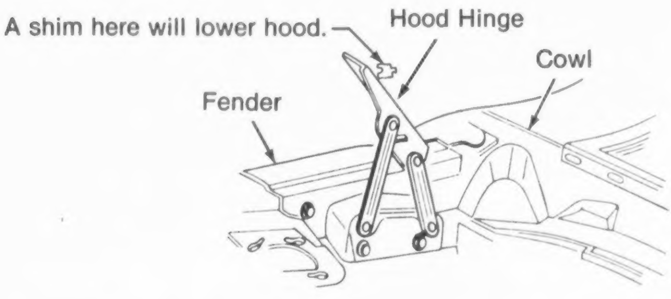
   b. Loosen retaining bolts holding hood to hinge

   c. Lift slightly on hinge, and place desired thickness of shim between hood and hinge

   (NOTE: The thickness of the shims and the number of shims needed depend on the distance the hood needs to be lowered or raised.)

      1) If hood is too high at cowl, place shim at front of hinge (Figure 59)

FIGURE 59



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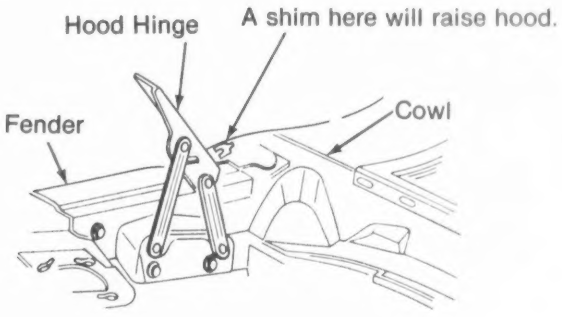
      2) If hood is too low at cowl, place shim at back of hinge (Figure 60)

FIGURE 60



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JOB SHEET #8

d. Place hinge in desired position, noting original scribed location of retaining bolts

e. Tighten retaining bolts

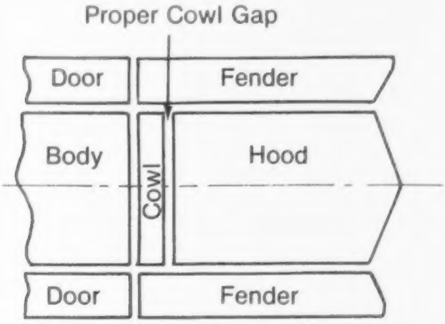
f. Close hood slowly and check for proper height at cowl

> **CAUTION**
>
> Avoid chipping the paint with the misaligned hood during the aligning and adjusting process.

g. If hood does not align with height of cowl, repeat process until desired height is obtained

F. Adjust hood to obtain proper clearance (gap) with cowl (Figure 61)

FIGURE 61



1. Use scratch awl to scribe onto hood panel original location of hinge
2. Loosen retaining bolts that hold hood hinge to hood panel
3. Wiggle hood back and forth to assure that movement can take place
4. Place hinge in desired position, noting original scribed location of retaining bolts
5. Tighten retaining bolts
6. Close hood slowly and check for proper clearance (1/8 to 1/4 inch) between hood and cowl

> **CAUTION**
>
> Avoid chipping the paint with the misaligned hood during the aligning and adjusting process.

JOB SHEET #8

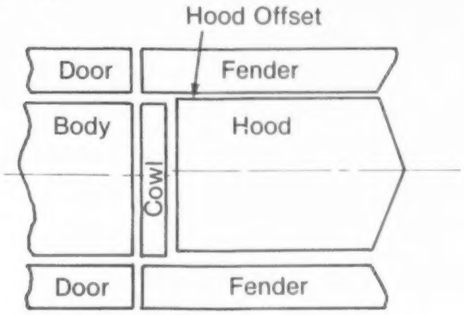
7. Check to see that all bolts are securely tightened

8. Measure to make sure that gap between hood and cowl is within tolerance

9. If gap is not within tolerance, repeat process until tolerance is obtained

G. Align left and right sides of hood with cowl (Figure 62)

FIGURE 62

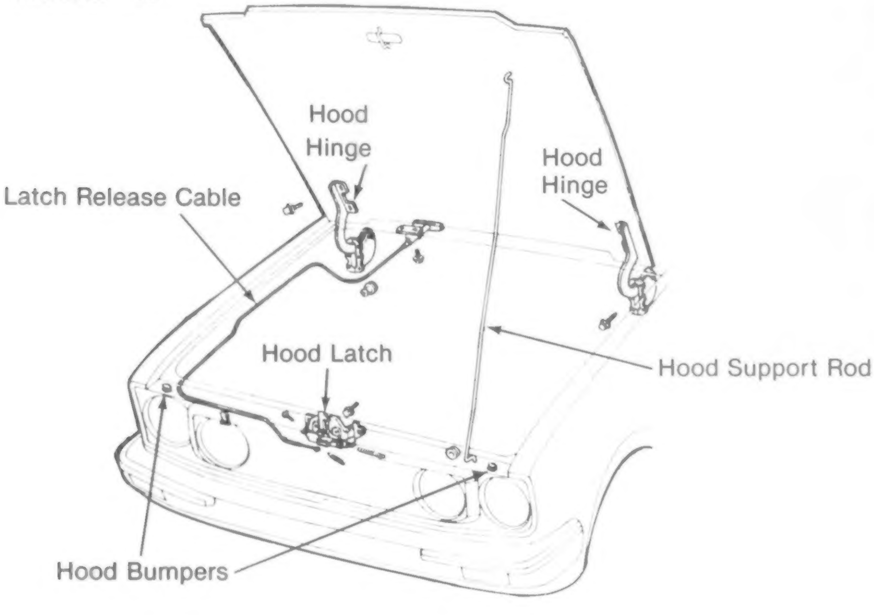


1. Raise hood

2. Push offset side of hood until edges of hood are in line with sides of cowl

H. Adjust hood bumpers to align hood flush with fenders (Figure 63)

FIGURE 63



From *Automotive Body Repair and Refinishing*, copyright 1980. Used with permission of Toyota Motor Sales Co., Ltd.

JOB SHEET #8

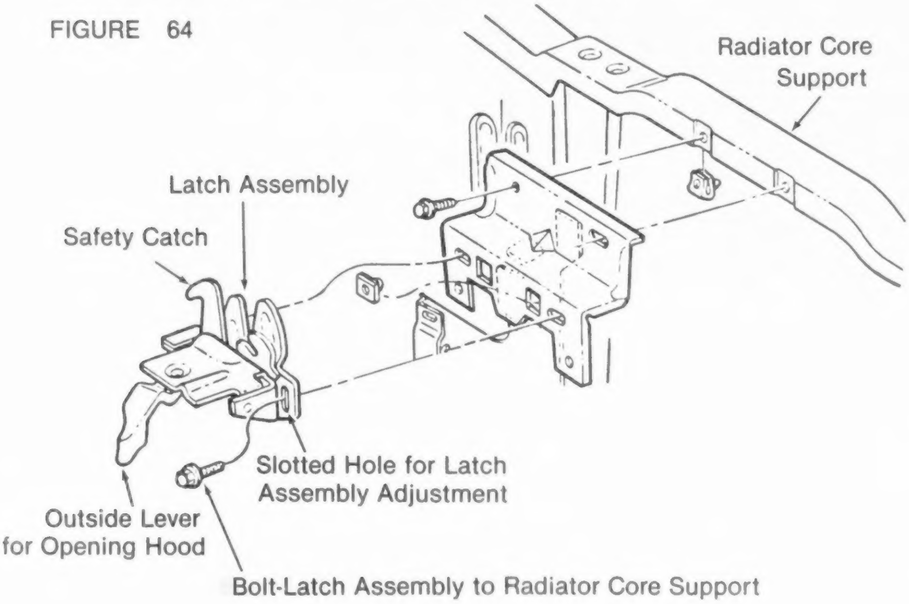
1. Open hood
2. Use appropriate combination-end wrench to loosen jamb nut on threaded shank of hood bumper

   (NOTE: Some hood bumpers do not have jamb nuts. If such is the case for the vehicle on which you are working, skip this step.)
3. Turn hood bumper clockwise by hand to lower and counterclockwise to raise as needed to align hood with fender
4. Retighten jamb nut on hood bumper shank if applicable
5. Close hood slowly to check for proper flush fit of hood to fenders

I. Align hood latch

(NOTE: There are many types of hood latches. The procedure outlined here is specific to the latch illustrated in Figure 64, but the general alignment method would be applicable to other types of latches.)

FIGURE 64


Radiator Core Support
Latch Assembly
Safety Catch
Slotted Hole for Latch Assembly Adjustment
Outside Lever for Opening Hood
Bolt-Latch Assembly to Radiator Core Support

From *Total Auto Body Repair*, 2nd ed., copyright 1983. Used with permission of Ford Parts and Service Division, Ford Motor Company.

1. Use scratch awl to scribe onto latch support the original location of latch retaining bolts
2. Lower hood until striker bar comes into contact with top of latch assembly

JOB SHEET #8

3. Note position of latch and striker bar, and correct for offset if necessary

   (NOTE: If the hood hinges are adjusted properly and the striker bar does not fit squarely into the "V" of the latch, a sideways latch adjustment must be made.)

   a. Loosen latch retaining bolts with combination-end wrench

   b. Note location of scribe marks, and move latch to desired side until alignment is obtained

      (NOTE: Alignment will be obtained when the striker bar fits squarely into "V" of latch. You will have to open and close the hood several times to check for proper fit.)

   c. Tighten retaining bolts with combination-end wrench

   d. Close hood again to check position of striker bar and latch "V"

   e. Readjust as needed until aligned

4. Correct hood latch height if necessary

   a. Shut hood completely and note ease with which latch catches

      (NOTE: If hood has to be slammed to latch, the latch adjustment is too low. If up-and-down slack can be felt in the hood after latching, the latch adjustment is too high.)

   b. Use scratch awl to scribe onto latch support the location of latch retaining bolts

   c. Loosen retaining bolts with combination-end wrench

   d. Note location of scribe marks, and move latch up or down as necessary

      CAUTION

      Do not move latch to either side, or side-to-side adjustment will be lost.

   e. Retighten retaining bolts with combination-end wrench

   f. Recheck hood latch adjustment by closing hood and checking ease of closing and up-and-down slack

   g. Readjust as needed until latch is at correct height

J. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #9 — ALIGN A FENDER

I. Equipment and materials

  A. Combination-end wrenches (standard or metric)

  B. 3/8-inch drive socket set

  C. Assorted body shims

  D. Straightedge

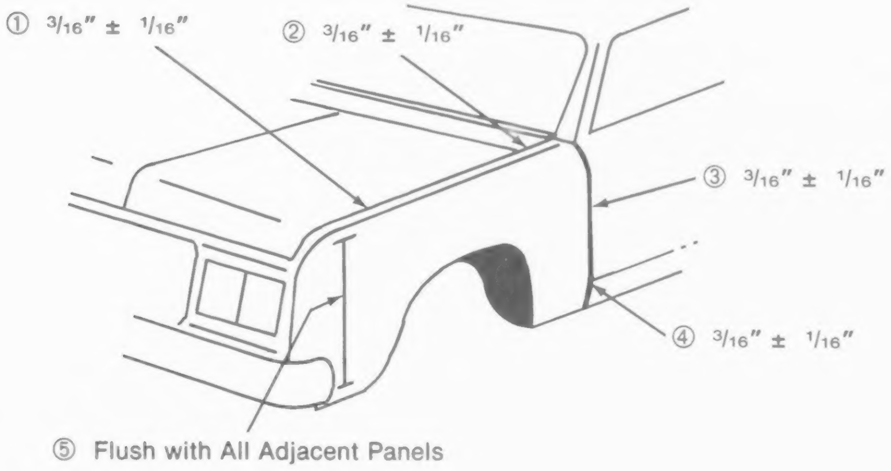
  E. Steel tape

  F. Eye protection

II. Procedure

  A. Check clearances by measuring with steel tape and straightedge; all clearances should be within 3/16 inch tolerance, plus or minus 1/16 inch, and fender should be flush with other panels (Figure 65)

  FIGURE 65



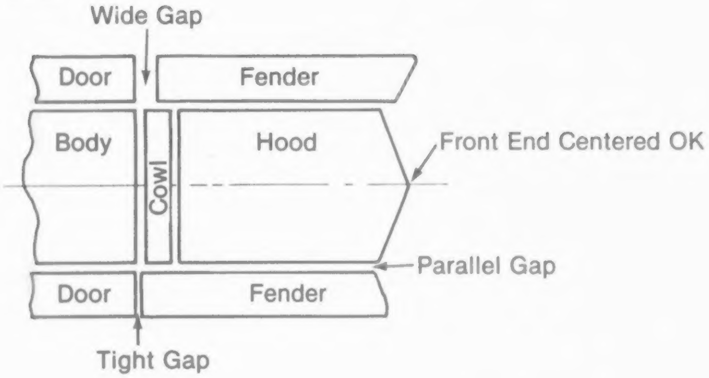
  B. Put on eye protection

  C. Make necessary forward or backward adjustments (See Figure 66)

  (NOTE: If the fender is too far back toward the door, it will be struck by the forward edge of the door as the door opens. Striking a misaligned fender with the door will chip the paint on the fender and may cause dents.)

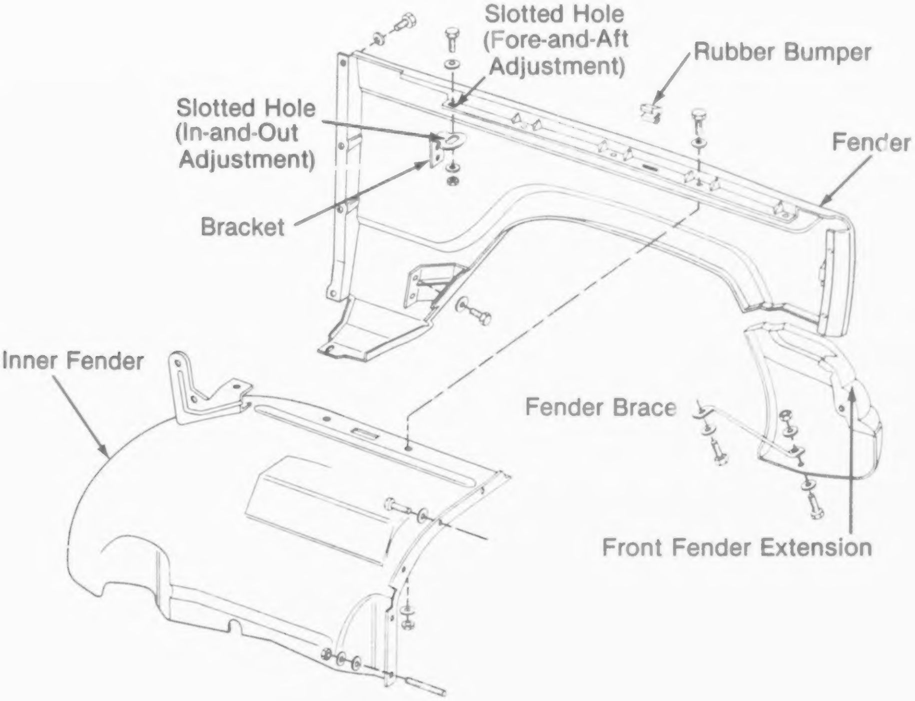
JOB SHEET #9

FIGURE 66



1. Raise hood to gain access to fender bolts (Figure 67)

FIGURE 67


Slotted Hole (Fore-and-Aft Adjustment)
Rubber Bumper
Slotted Hole (In-and-Out Adjustment)
Fender
Bracket
Inner Fender
Fender Brace
Front Fender Extension

From *Automotive Body Repair and Refinishing*, copyright 1980. Used with permission of American Motors Corporation.

JOB SHEET #9

2. Use sockets or wrenches to loosen bolts at radiator support, along inner fender, and at top and bottom of cowl
3. Move fender forward or back to desired position

   (NOTE: A pry bar or body jack may have to be used to provide enough pressure to align the fender.)

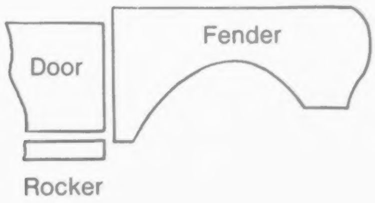
4. Place shims in any bolt location that does not fit flush against metal or will pull fender out of alignment when tightened

   EXAMPLE: Between cowl and fender

5. Use proper wrenches to tighten all fender bolts
6. Close hood and check forward or back clearances; realign if necessary

D. Make necessary up or down adjustments (Figure 68)

FIGURE 68



1. Make alignment check and determine whether fender needs to move up or down
2. Raise hood to gain access to fender bolts (See Figure 70)
3. Loosen bolts in cowl area and those in inner fender if necessary
4. Raise horizontally mounted fender by adding shims at upper cowl bolt and removing shims at bottom cowl bolt (Figures 69 and 70)

FIGURE 69: Add shims at upper fender section.

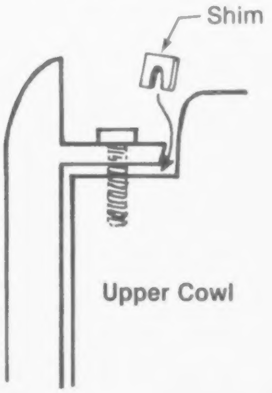
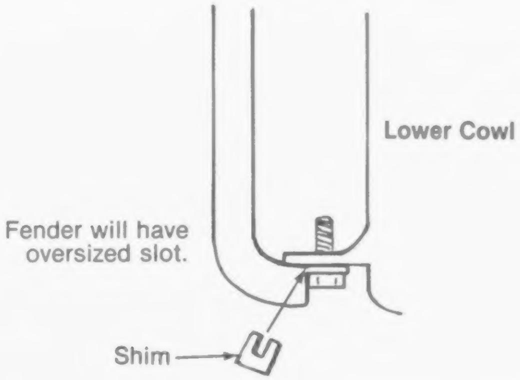


FIGURE 70: Remove shims at lower lower fender section.



JOB SHEET #9

5. Lower horizontally mounted fender by removing shims at upper cowl bolt and adding shims at lower cowl bolt

6. Raise or lower vertically mounted fender by simply loosening bolts and moving fender up or down as needed (Figures 71 and 72)

FIGURE 71: Upper fender section

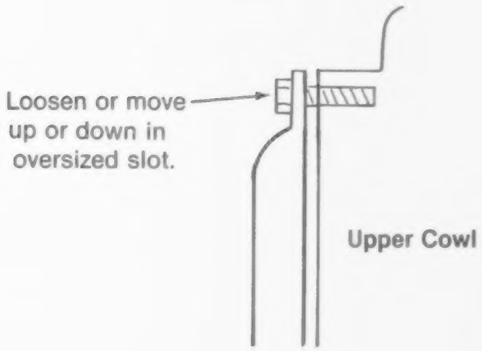
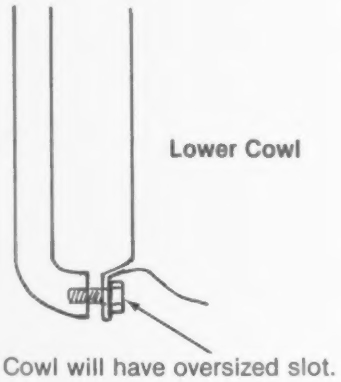


FIGURE 72: Lower fender section

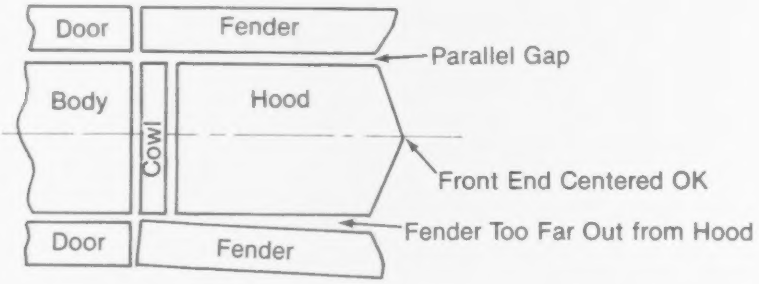


7. Retighten bolts and check clearance with straightedge; readjust as necessary

E. Make necessary in-or-out adjustments (Figure 73)

(NOTE: If the fender is too far in toward the hood, it may be hit by the hood as the hood closes. Striking a misaligned fender with the hood will chip the paint on the fender and may cause dents.)

FIGURE 73



JOB SHEET #9

1. Make alignment check and determine whether fender needs to move in or out
2. Raise hood to gain access to fender bolts
3. Loosen bolts at radiator support, along inner fender, or at upper or lower cowl as needed
4. Move horizontally mounted fender in or out by moving bolt in oversized slot until fender is in desired location (Figures 74 and 75)

FIGURE 74: Upper fender section

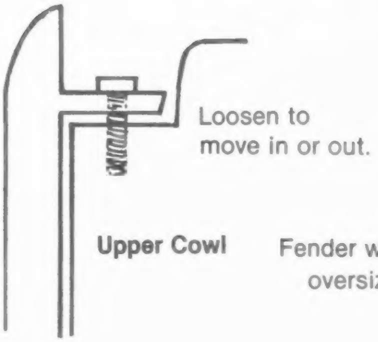
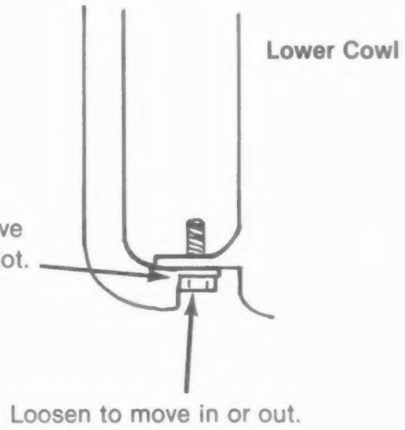


FIGURE 75: Lower fender section

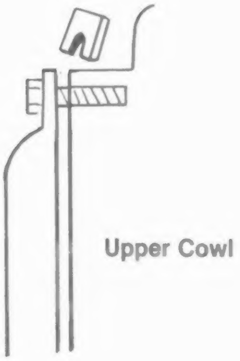


5. On vertically mounted fender, add shims at upper and lower cowl to move fender out; remove shims at upper and lower cowl to move fender in (See Figures 76 and 77)

   (NOTE: Some fenders have both vertical and horizontal mounting points. These fenders require the use of both methods.)

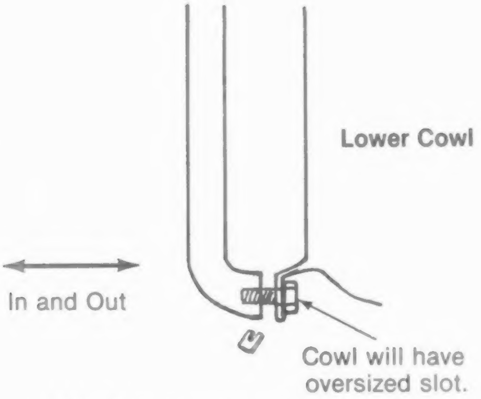
JOB SHEET #9

FIGURE 76: Upper fender section



Add shim to move out;
remove shim to move in.

FIGURE 77: Lower fender section



Add shim to move out;
remove shim to move in.

6. Retighten all fender bolts

7. Close hood slowly and check fender-to-hood clearance with steel tape and straightedge; readjust as necessary

F. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #10 — ALIGN A DOOR

I. Equipment and materials

   A. Combination-end wrenches

   B. 3/8-inch and 1/4-inch socket sets

   C. Door-hinge wrenches

   D. Steel tape

   E. Pencil and paper for writing dimensions

   F. Torx bits

   G. Door-hinge aligning tool

   H. 3-pound hammer

   I. Scratch awl

   J. Wooden block

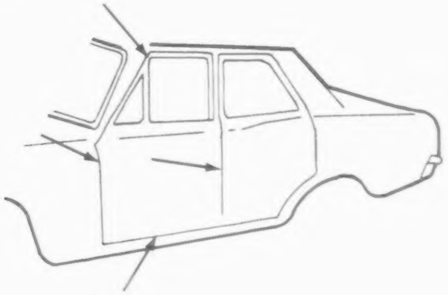
   K. Eye protection

   L. Appropriate service manual

II. Procedure for aligning bolted doors

   A. Check door clearances by measuring with steel tape and straightedge; all clearances should be within 3/16 inch tolerance, plus or minus 1/16 inch, and fender should be flush (Figure 78)

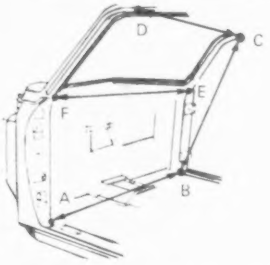
FIGURE 78



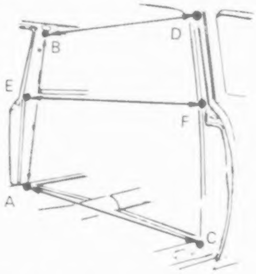
JOB SHEET #10

B. Check door opening for square by measuring and checking measurements with specifications in service manual (Figure 79)

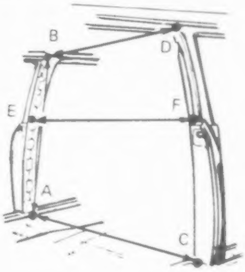
FIGURE 79



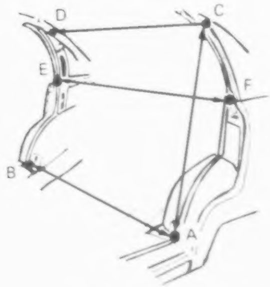
Front pillar horizontal and vertical measuring points



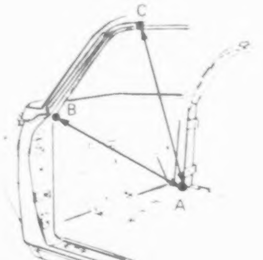
Lock pillar horizontal and vertical measuring points



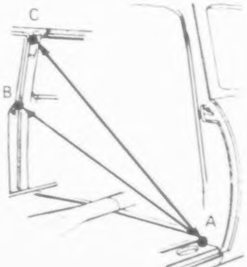
Center pillar horizontal and vertical measuring points



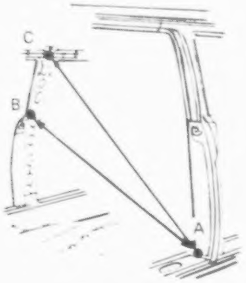
Rear lock pillar horizontal and vertical measuring points



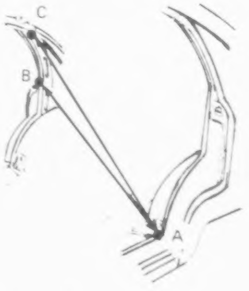
Front pillar diagonal measuring points



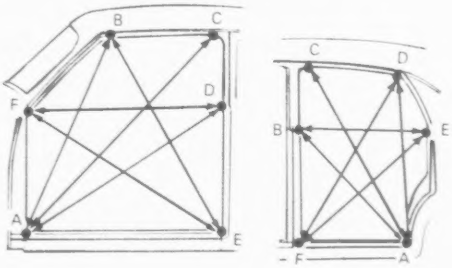
Lock pillar diagonal measuring points



Center pillar diagonal measuring points



Rear lock pillar diagonal measuring points



Front and rear door openings measuring points

JOB SHEET #10

C. Open door and find door-hinge-to-pillar retaining bolts (Figures 80 and 81)

FIGURE 80: Front door

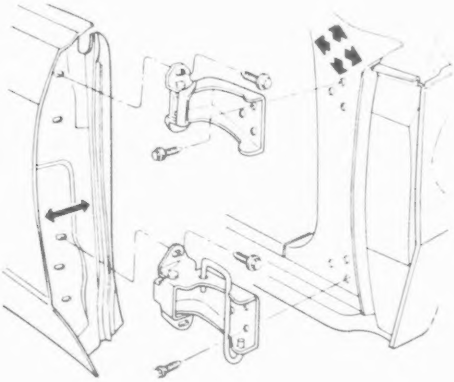
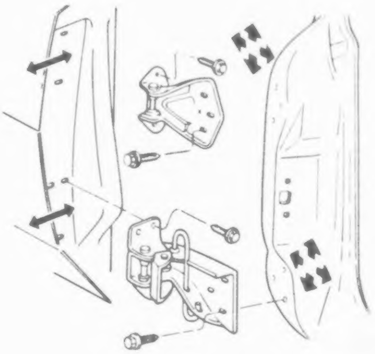


FIGURE 81: Rear door



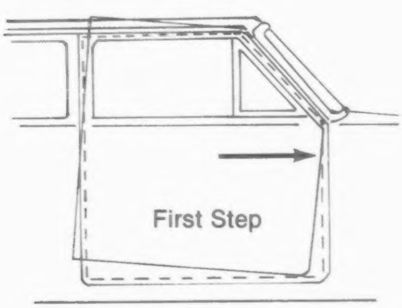
Figures 80 and 81 from *Total Auto Body Repair*, 2nd ed., copyright 1983. Used with permission of Ford Parts and Service Division, Ford Motor Company.

D. Study access to hinges and determine suitable tool for loosening bolts (door hinge wrench, combination-end wrench, ratchet set, etc.)

E. Loosen bolts on top hinge

F. Apply upward and forward pressure on unhinged edge of door to move top hinge forward to desired position (Figure 82)

FIGURE 82: Moving door ahead at top hinge



(NOTE: In some cases, sealer buildup around the hinges will prevent movement. In such cases, place a wooden block against the hinge and give it a few sharp blows with a 3-pound hammer to loosen the sealer so that movement can take place.)

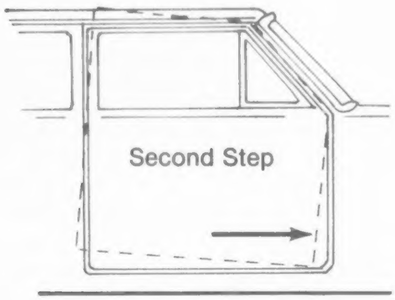
JOB SHEET #10

G. When top hinge is in correct position, tighten upper hinge bolts

H. Loosen bolts on bottom hinge

I. Slide bottom hinge forward to desired position (Figure 83)

FIGURE 83: Moving door ahead at bottom hinge

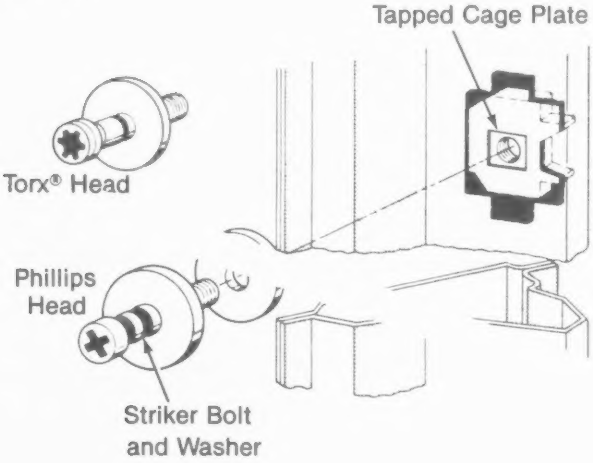


J. Retighten bottom hinge bolts

K. Close door and check for proper alignment; if door is not aligned within tolerance, repeat procedure

L. Adjust door striker (Figure 84)

FIGURE 84



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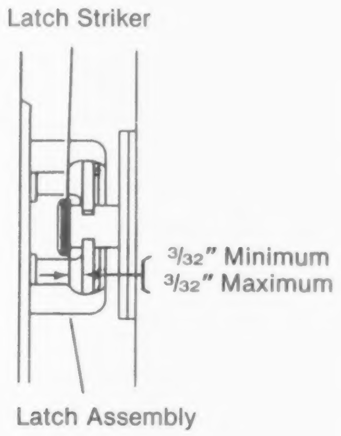
JOB SHEET #10

1. Close door until striker bar or bolt comes in contact with door latch assembly (Figure 85)

FIGURE 85



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2. Note position of latch and striker bolt

   (NOTE: If striker bolt does not fit squarely into latch opening, adjustment is necessary.)

3. Open door and examine striker bolt to determine the tool needed to loosen it

4. Use scratch awl to scribe original location of striker bolt assembly

5. Loosen striker bolt by turning it counterclockwise with appropriate tool

6. Move bolt assembly to new position, noting original scribed position

7. Retighten striker bolt by turning clockwise with appropriate tool

8. Close door to check position of striker bolt in latch opening; if bolt does not fit squarely, repeat steps until proper fit is obtained

9. Close door and note pressure required to latch

   (NOTE: If too much pressure is required, the striker bolt is too far in; if door does not fit snugly at the rear, the striker bolt is too far out.)

10. If in-or-out adjustment is necessary, open door and use scratch awl to scribe vertical position on striker-bolt assembly

JOB SHEET #10

11. Loosen striker bolt, using appropriate tool

12. Move striker bolt horizontally either in or out until desired position is obtained

13. Retighten striker bolt with appropriate tool

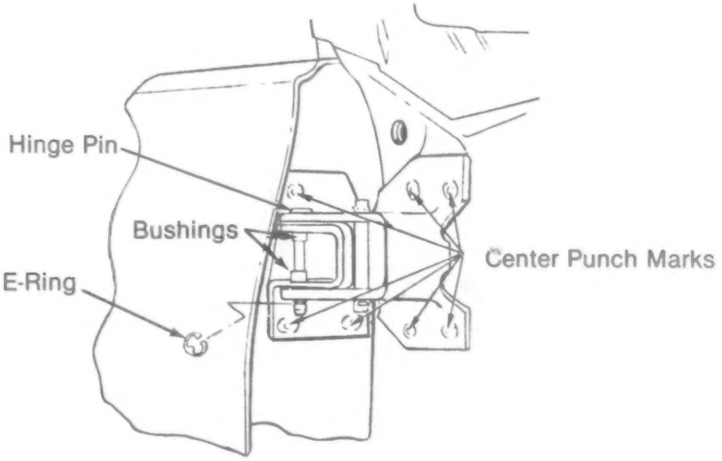
14. Check door for proper fit and ease of opening and closing

M. Clean work area and return equipment and materials to proper storage

III. Procedure for aligning door with welded hinges (Figure 86)

(NOTE: Because doors with welded-on hinges have no built-in adjustments, they must be adjusted by bending the hinges or the door to achieve the proper alignment.)

FIGURE 86



Used with permission of Chevrolet Motor, General Motors Corporation.

A. Examine closed door to determine what clearance adjustments must be made

B. Open door and shake up and down at handle edge to determine wear to hinges

(NOTE: If there is excessive up-and-down movement in the door, the hinges will need to be rebuilt or replaced before alignment can take place. To rebuild or replace a hinge, refer to the service manual for the vehicle on which you are working.)

C. Adjust for sag by bending hinge

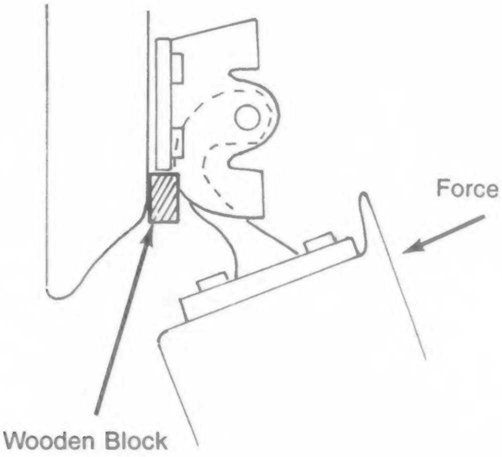
1. Open door fully

JOB SHEET #10

2. Place door-hinge aligning tool between door-hinge arm and hinge pillar of upper hinge (Figure 87)

   (NOTE: This method may also be used on the lower hinge if needed.)

FIGURE 87



3. Hold tool and close door slowly until hinge contacts tool

4. Apply inward pressure on rear of door to help bend hinge

   (NOTE: Pressure must be applied a little at a time and the door must be checked often so that overcorrections will not take place.)

5. Open door and remove tool

6. Close door and check alignment; repeat procedure if necessary until door is properly aligned

D. Adjust for sag by bending door frame

1. Open door fully

2. Attach door-hinge alignment tool to striker and lock

3. Close door until it is about one-third open

4. Pry upward a little past desired location to allow for spring back

JOB SHEET #10

6. Remove tool from door and check alignment; repeat procedure if necessary until door is properly aligned

E. Adjust door striker as described in procedure II L of this job sheet

F. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #11 — ALIGN A DECK LID AND CHECK FOR PROPER SEAL

I. Equipment and materials

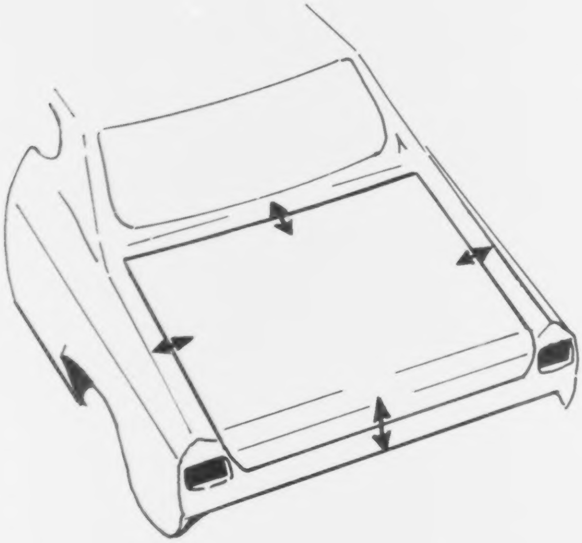
- A. Combination-end wrenches
- B. 3/8-inch drive socket set
- C. Straightedge
- D. Scratch awl
- E. Steel tape
- F. Assorted body shims
- G. Oxyacetylene torch and heating attachment
- H. Protective clothing and full-face shield
- I. 4-ton hydraulic or mechanical jack set
- J. 2″×2″ wood or metal block
- K. Plastic filler
- L. Air-dry vinyl sealer
- M. Caulking material
- N. Water hose and power nozzle
- O. Replacement weatherstripping and adhesive (if necessary)
- P. Appropriate service manual

II. Procedure

- A. Close deck lid and check clearances with steel tape and straightedge; all clearances should be within 3/16 inch tolerance plus or minus 1/16 inch, and deck lid should be flush with adjacent panels (See Figure 88)

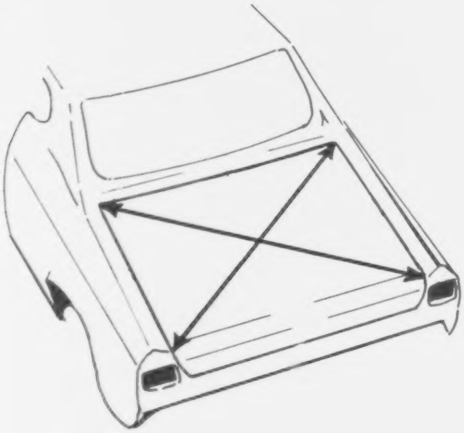
JOB SHEET #11

FIGURE 88



B. Check opening for square by measuring from corners of opening directly across to opposite corners and comparing to manufacturer's specifications (Figure 89)

FIGURE 89



C. Align lid, following whichever of the following methods is applicable

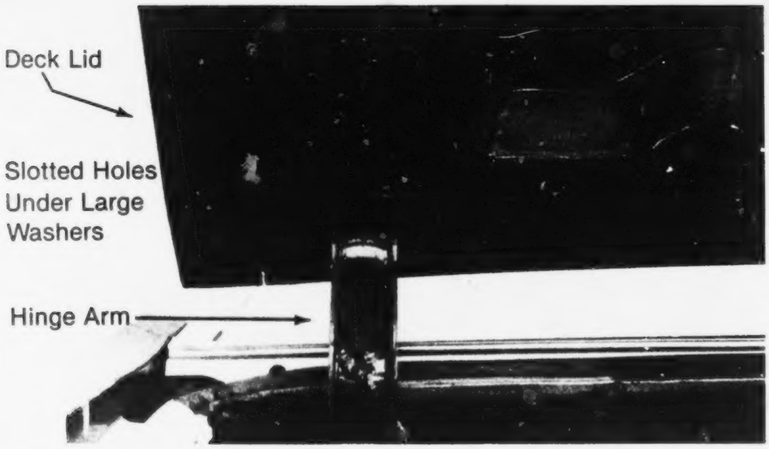
1. Adjust lid for misalignment in forward, back, or side clearance

   a. Raise deck lid

   b. Use scratch awl to scribe original location of hinge-to-deck-lid retaining bolts (See Figure 90)

JOB SHEET #11

FIGURE 90



c. Loosen retaining bolts on one side with combination-end wrench

d. Move deck lid forward or back to desired location, noting original scribed position of hinge

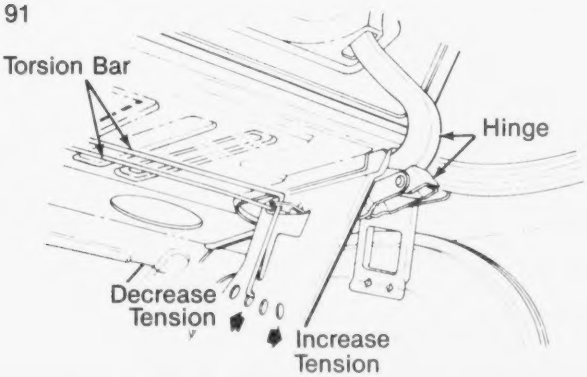
e. Tighten retaining bolts and repeat this procedure for other hinge

f. Close deck lid and check for desired fit; if fit is not within tolerance, repeat process until desired fit is obtained

2. Add shims to level deck lid that is too high or too low at hinged edge

   (NOTE: If the deck lid has horizontal retaining bolts, as shown in Figure 91, the shimming process is not needed and does not apply.)

FIGURE 91



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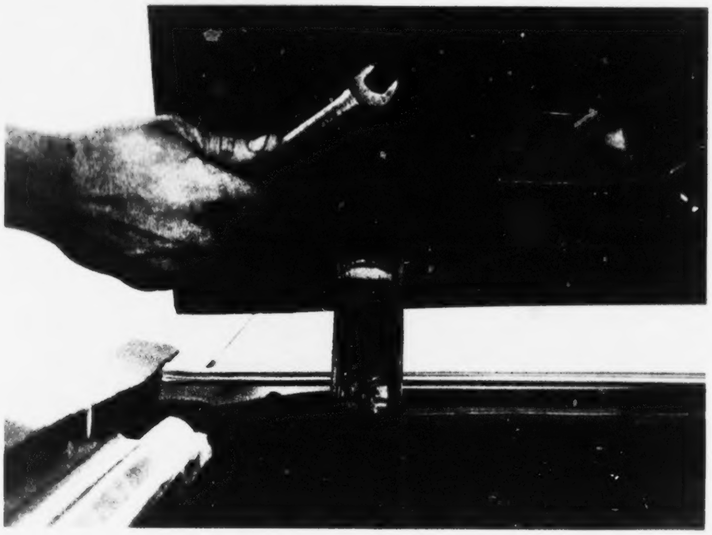
JOB SHEET #11

a. Close lid and check for misalignment

b. Use scratch awl to scribe original location of hinge-to-deck-lid retaining bolts

c. Loosen deck-to-hinge retaining bolts (Figure 92)

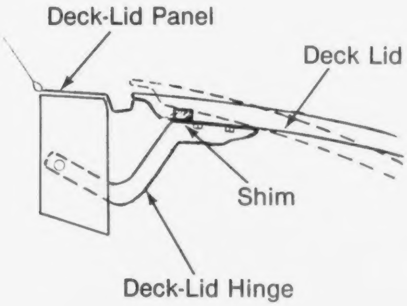
FIGURE 92



d. Lift rear of deck lid to allow a gap to form between deck lid and hinge

e. If deck lid is low at hinged edge, place shims of desired thickness at *front* of hinge as shown in Figure 93

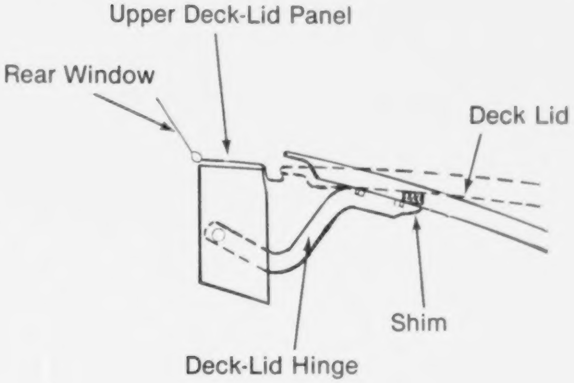
FIGURE 93



JOB SHEET #11

f. If deck lid is high at hinged edge, place shims of desired thickness at *back* of hinge as shown in Figure 94

FIGURE 94



g. Position deck lid in correct alignment, noting original scribed location of retaining bolts

h. Tighten retaining bolts with combination-end wrench

i. Close deck lid slowly and check for proper height in relation to rear deck panel and quarter panels; if fit is not within tolerance, repeat process, either adding or removing shims until proper height is obtained

3. Bend hinges to level deck lid that is too low at hinged edge

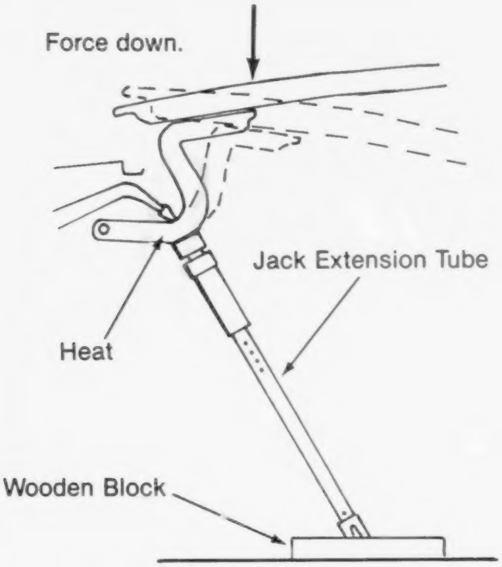
   a. Close deck lid and check for misalignment

   b. Raise deck lid and place a wooden block on floor of trunk in line with hinge

   c. Position hydraulic or mechanical jack between block and bottom curve of hinge as shown in Figure 95

JOB SHEET #11

FIGURE 95: Bending the deck-lid hinge



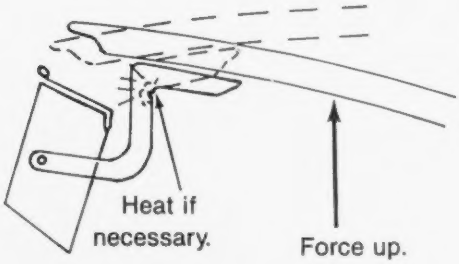
d. Apply light pressure to hinge with body jack

e. Put on protective clothing and full-face shield

f. Set up with heating attachment, light, and adjust oxyacetylene torch

g. Apply light heat to bottom curve of hinge until hinge turns a dull red color (Figure 96)

FIGURE 96



h. Turn off torch and quickly set aside

i. Force hinged edge of deck lid down with your hands, while hydraulic or mechanical jack maintains pressure at hinge

j. Let metal cool and then release body jack

JOB SHEET #11

k. Repeat steps for opposite hinge

l. Close lid slowly and check for proper height; if fit is not within tolerance, repeat procedure until desired height is obtained

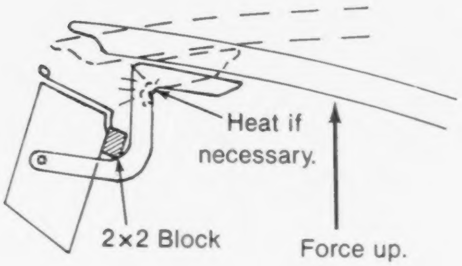
4. Bend hinges to level deck lid that is too high at hinged edge

   a. Close deck lid and check for misalignment

   b. Raise deck lid until it is about two-thirds open

   c. Place small 2"×2" block between hinge at lower curve and rear deck support shelf (Figure 97)

FIGURE 97



   d. Hold block and let deck lid open until hinge rests against block at lower hinge curve

   e. Apply upward pressure to hinged edge of deck lid to reshape hinge curve

   (NOTE: Mild heat may have to be applied to the hinge at the lower curve. If so, follow appropriate heating steps as outlined in procedure for leveling a deck lid that is too low at hinged edge.)

   f. If hinge was heated, let it cool before lowering deck lid a little and removing block from hinge

   g. Repeat process on opposite hinge if necessary

   h. Close deck lid slowly and check for proper height; if fit is not within tolerance, repeat process until proper height is obtained

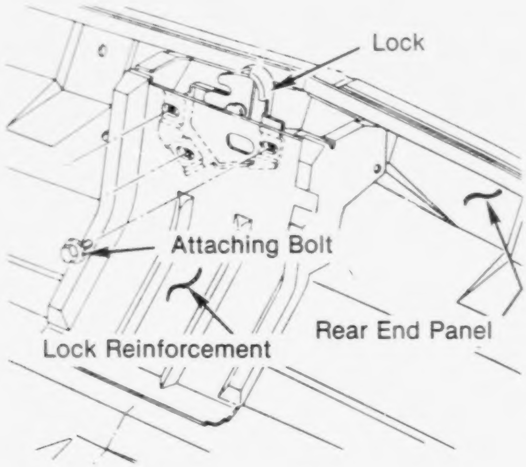
5. Adjust deck-lid bumpers by turning by hand, either clockwise to lower lid or counterclockwise to raise lid

   (NOTE: This method applies only to certain models, as some models do not have deck-lid bumpers.)

JOB SHEET #11

D. Align deck-lid latch (Figure 98)

FIGURE 98



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1. Use scratch awl to scribe onto latch support original location of latch retaining bolts

2. Lower deck lid until striker bar comes into contact with top of latch assembly

3. Note position of latch and striker bar, and correct for offset if necessary

   (NOTE: If deck hinges are adjusted properly and the striker bar does not fit squarely into latch opening, a sideways latch adjustment must be made.)

4. Loosen latch retaining bolts with combination-end wrench

5. Note location of scribe marks, and move latch to desired side until alignment is obtained

   (NOTE: Alignment will be obtained when the striker bar fits squarely into the latch opening. You will have to open and close the deck lid several times to check for proper fit.)

6. Tighten retaining bolts with combination-end wrench

7. Close deck lid again and check position of striker bar and latch opening

8. Readjust as needed until aligned

JOB SHEET #11

E. Correct deck-lid latch height if necessary

1. Shut deck lid completely and note ease with which latch catches

   (NOTE: If lid has to be slammed to latch, the latch adjustment is too low. If up-and-down slack can be felt in the lid after latching, the latch adjustment is too high.)

2. Use scratch awl to scribe onto latch support the location of latch retaining bolts
3. Loosen retaining bolts with combination-end wrench
4. Note location of scribe marks, and move latch up or down as necessary

   CAUTION

   Do not move latch to either side, or side-to-side adjustment will be lost.

5. Retighten retaining bolts with combination-end wrench
6. Recheck deck latch adjustment by closing deck lid and checking ease of closing and up-and-down slack
7. Readjust as needed until deck-lid latch is at correct height

F. Check deck-lid seal

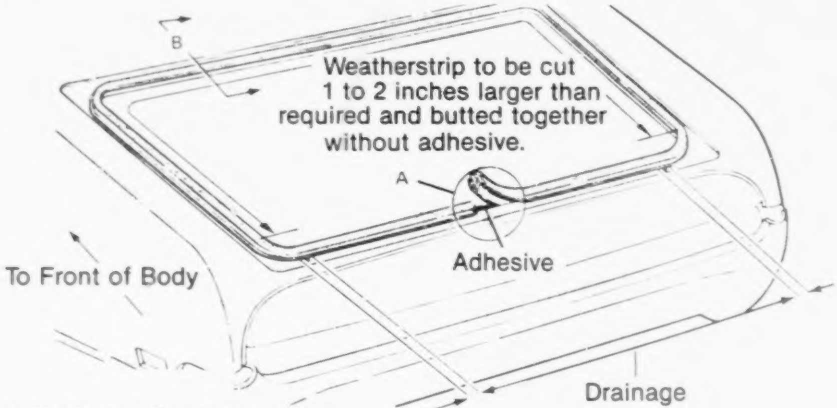
1. Close deck lid
2. Direct a stream of water at joint between lid and adjacent quarter panel, carrying stream all the way around lid
3. Open deck lid and look for wet spots on inside of weatherstripping and for water on floor of trunk
4. If seal is faulty, repair, following whichever of the following methods is applicable
   a. If low spots at body solder or weld joints are cause of leakage, build up low spots with plastic filler
   b. If seams or pinholes are cause of leakage, repair with air-dry vinyl or equivalent sealer
   c. If end extension or taillights are cause of leakage,
      1) Check for loose or missing nuts or screws
      2) Replace and tighten nuts and screws as necessary
      3) Apply caulking material around nuts and screws to seal them

JOB SHEET #11

5. Close deck lid and redirect stream of water around lid to check for proper seal

6. If seal is still faulty, repair again or replace weatherstripping as shown in Figures 99 through 101

FIGURE 99


B
Weatherstrip to be cut 1 to 2 inches larger than required and butted together without adhesive.
A
Adhesive
To Front of Body
Drainage

(NOTE: Omit adhesive around drainage depressions.)

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FIGURE 100

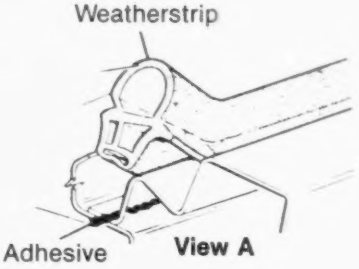
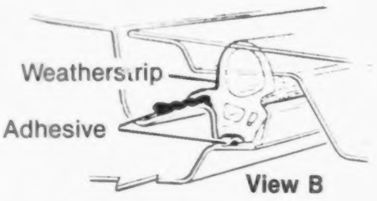


FIGURE 101



Figures 100 and 101 from *Automotive Body Repair and Refinishing*, copyright 1980. Used with permission of Ford Parts and Service Division, Ford Motor Company.

G. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

JOB SHEET #12 — INSPECT, TEST, AND ALIGN A HYDRAULIC IMPACT-ABSORBING BUMPER

I. Equipment and materials

   A. Combination-end wrenches

   B. Power jack set

   C. Chain or cable

   D. Eye protection

   E. Pneumatic drill motor

   F. $^1/_8$-inch drills

   G. Air compressor

   H. Floor jack

   I. Level

   J. Straightedge

   K. Steel tape

   L. Appropriate service manual

II. Procedure

   A. Make visual inspection

      1. Check for leakage; if oil is dripping continuously from crimp or stud end of unit, unit must be replaced

         (NOTE: Some oil wetting may be visible due to the grease packed in the crimp recess. Therefore, a stain or trace of oil on the piston tube near the crimp is normal.)

      2. Assess damage by examining the piston tube, bumper bracket, frame bracket, and cylinder tube for evidence of visible distortion; if there is obvious damage, the unit must be replaced

         (NOTE: Scuffing of the piston tube will occur when the unit is stroked and is considered normal.)

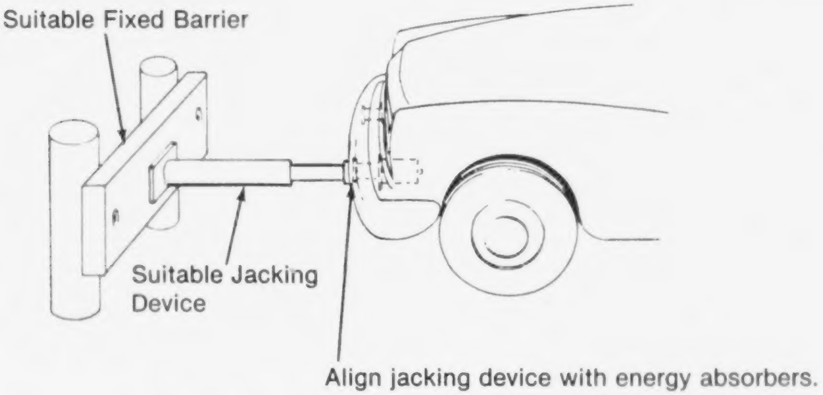
JOB SHEET #12

B. Put on eye protection

C. Test energy-absorber operation

1. Position vehicle before a suitable fixed barrier such as a pillar, wall, post, or other anchorable fixture
2. Turn ignition to OFF, place selector lever in PARK, set parking brake, and apply service brake
3. Position power jack between bumper and barrier so that jack is positioned squarely with bumper and directly in line with energy absorber to be checked (Figure 102)

FIGURE 102



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4. Apply pushing pressure with jack to compress energy absorber at least 3/8 inch, using indicator to detect exact amount of travel

> **CAUTION**
>
> Stand clear of bumper and handle equipment with care to avoid personal injury or damage to vehicle.

5. Release jack pressure and check indicator to determine whether energy absorber returned to its original position; if it did not, it must be replaced
6. Repeat steps 3 through 5 for second energy absorber

D. Remove and replace energy absorber(s) as necessary

> **CAUTION**
>
> Stand clear of bumper at all times.

JOB SHEET #12

1. Provide a positive restraint, such as a chain or cable, to hold bumper in position it is in

2. Insert drill into drill motor chuck, tighten with chuck key, and hook up drill motor to compressor

4. Release pressure in absorber by drilling hole in piston tube near bumper bracket

5. Unhook drill from compressor

6. Use combination-end wrench to remove energy absorber by removing retaining bolts from absorber and frame as shown in Figure 103 or 104

FIGURE 103: Front assembly

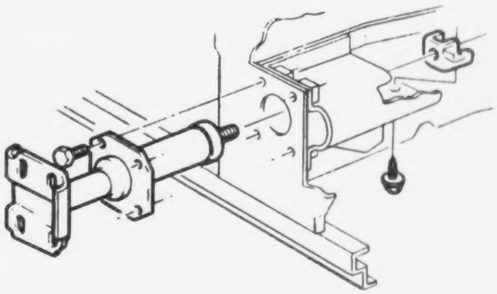
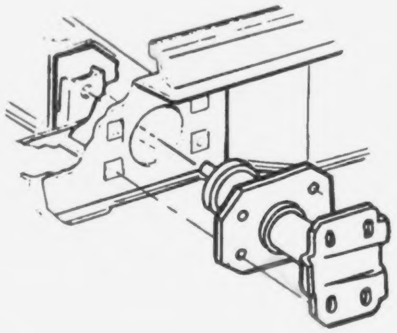


FIGURE 104: Rear assembly



Figures 103 and 104 used with permission of Chevrolet Motor Division, General Motors Corporation.

7. Discard old absorber and install new absorber, tightening retainer bolts securely

8. Repeat process on second absorber as necessary

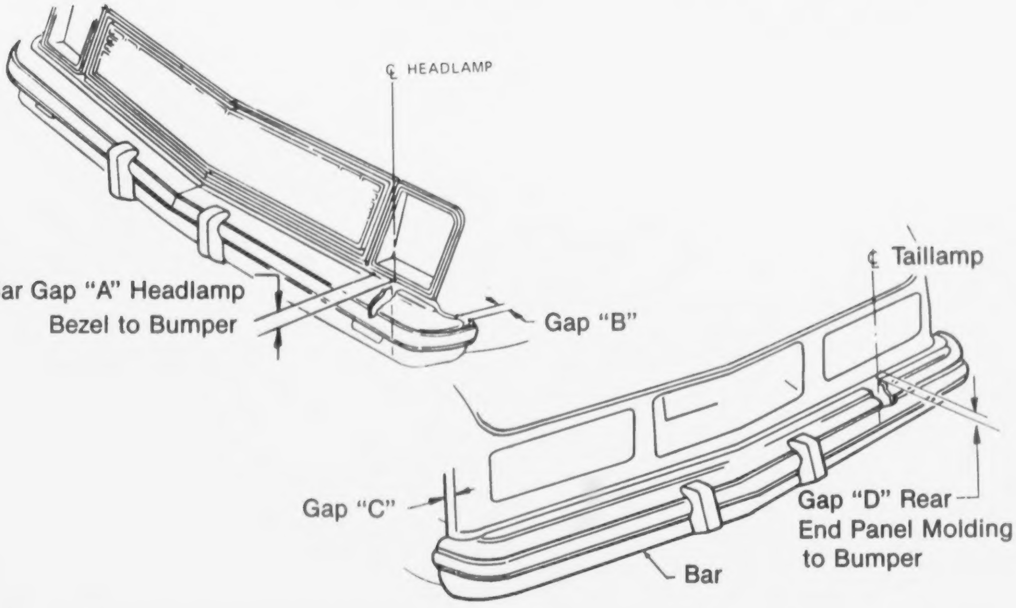
E. Align bumper

1. Use steel tape and hand level to check clearances

   (NOTE: Bumper alignment specifications may be obtained in the body service manual for the specific make and model vehicle you are working on. See Figure 105.)

JOB SHEET #12

FIGURE 105


℄ HEADLAMP
℄ Taillamp
Bar Gap "A" Headlamp Bezel to Bumper
Gap "B"
Gap "C"
Gap "D" Rear End Panel Molding to Bumper
Bar

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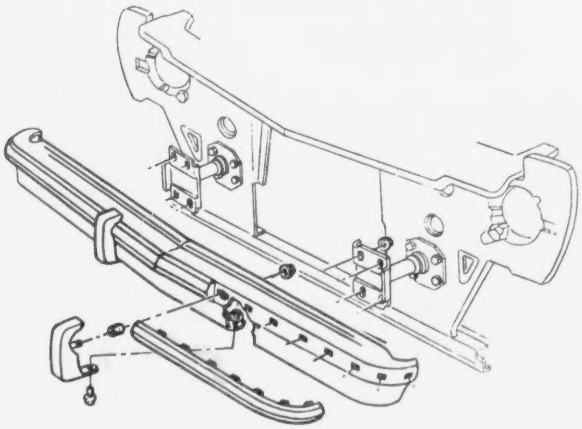
2. Use combination-end wrench to loosen energy-absorber nuts on each side of bumper (Figure 106 or 107)

   (NOTE: Loosening these nuts allows for both up-and-down and side-to-side adjustment of bumper.)

FIGURE 106: Typical front bumper assembly



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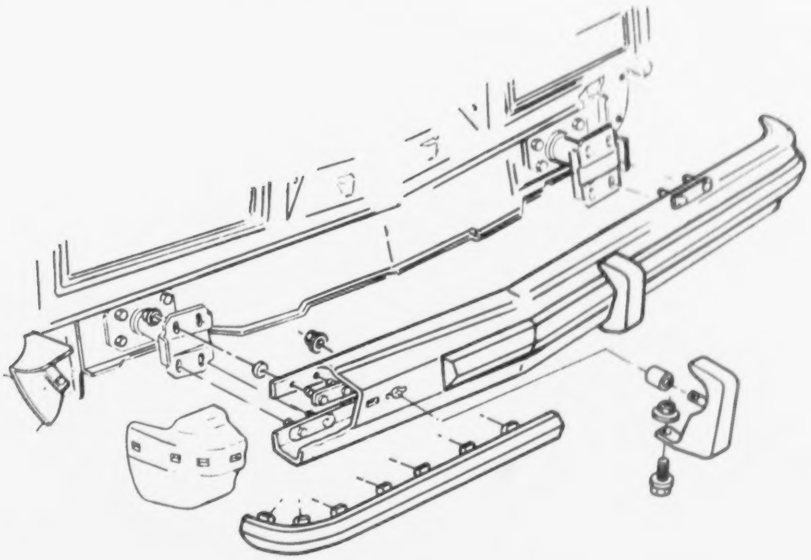
JOB SHEET #12

FIGURE 107: Typical rear bumper assembly



Used with permission of Chevrolet Motor Division, General Motors Corporation.

3. Align bumper to proper specifications and support with floor jack
4. Tighten energy-absorber nuts
5. Recheck clearance with steel tape and hand level; if clearances are not within tolerance, repeat procedure until proper alignment is obtained

F. Clean work area and return equipment and materials to proper storage

ROUGHOUT
UNIT II

TEST

NAME ____ SCORE ________________

1. Match to their correct definitions terms associated with vehicle roughout. Write the correct numbers in the blanks.

_____a. Pulling force; metal that is pushed down

_____b. Collision damage caused by impact force traveling through direct-damage area and damaging other areas of the same panel or other panels and areas

_____c. Body repair stage in which dimensions are established and damaged panels are aligned and reshaped to proper dimensions

_____d. Point to which metal can be stretched and still recover

_____e. Compression of metal; opposite of stretch

_____f. Pushing force or point of direct damage to body panel; metal that is pushed up

_____g. Change of granular structure of metal by bending or forming, which causes metal to become hardened or strengthened in the bend

_____h. Swelling and thinning of metal due to improper hammer and dolly technique; can also result from bending and pulling

_____i. Collision damage at point of impact and in immediate surrounding area

1. Elastic limit
2. Tension
3. Upset
4. Pressure
5. Roughout
6. Work hardening
7. Direct damage
8. Indirect damage
9. Stretch

2. Arrange in order the steps in assessing auto-body metal damage. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Decide method of repair

_____b. Note extent of damage

_____c. Determine order of repair

_____d. Classify damage and type of sheet metal

_____e. Make necessary alignment checks

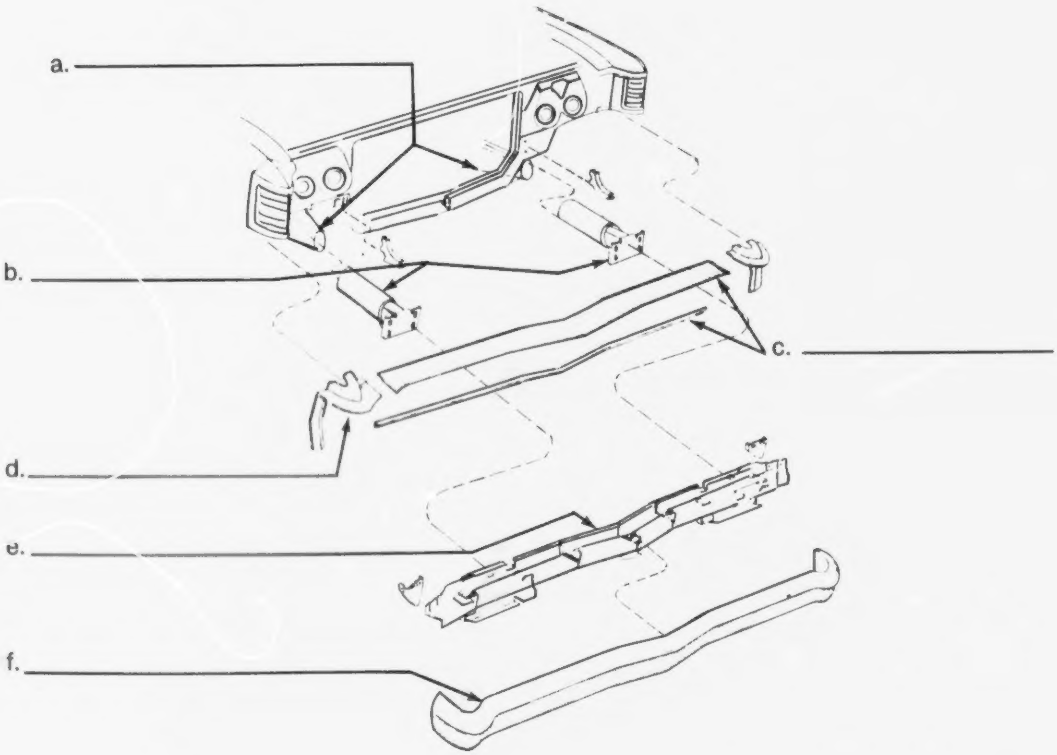
TEST

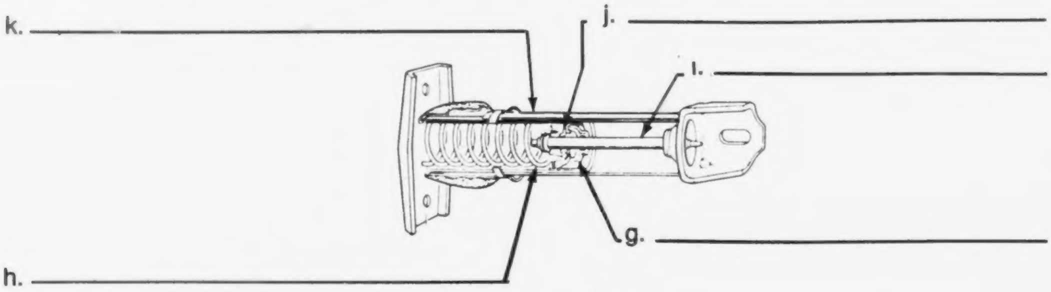
3. State the purpose of aligning detachable parts.

____

____

4. Label the basic parts of the impact-absorbing bumper assembly illustrated below.





TEST

5. State six safety rules to follow when handling hydraulic energy absorbers.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

6. List factors to consider when roughing out auto-body sheet metal.

   a. ______________________________

   b. ______________________________

   c. ______________________________

7. Describe the effects of bending auto-body sheet metal.

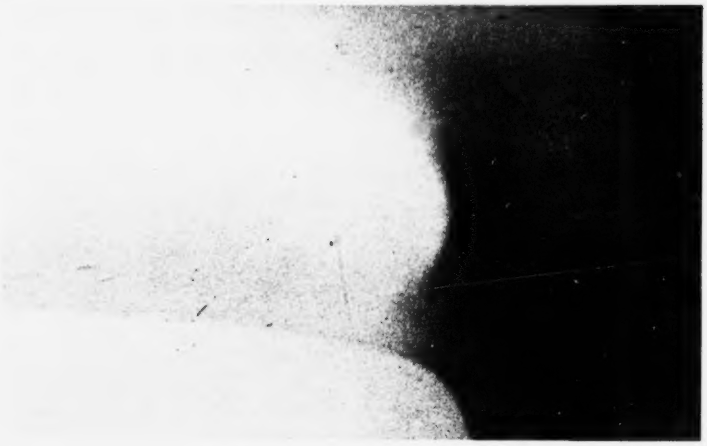
   ____

   ____

   ____

8. Identify the classes of metal damage shown in the following illustrations. Write the correct names in the blanks.

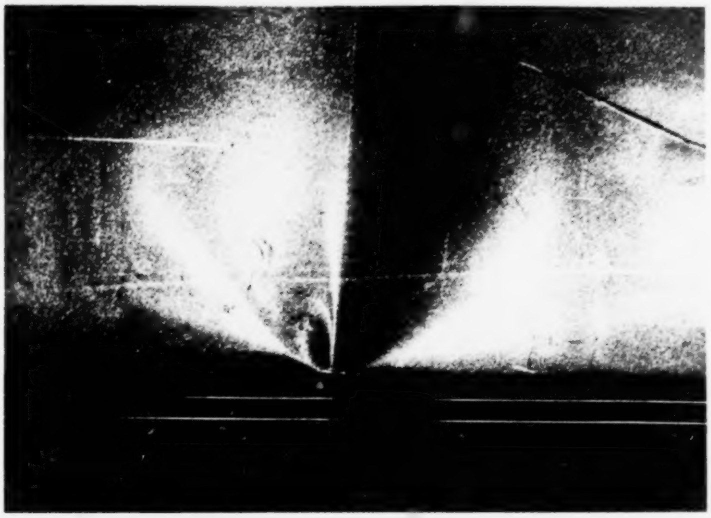
Buckle
Tear
Gouge
Eyebrow
Hinge
Rolled buckle
Compression or wrinkle
Collapsed box section



a. ______________________________

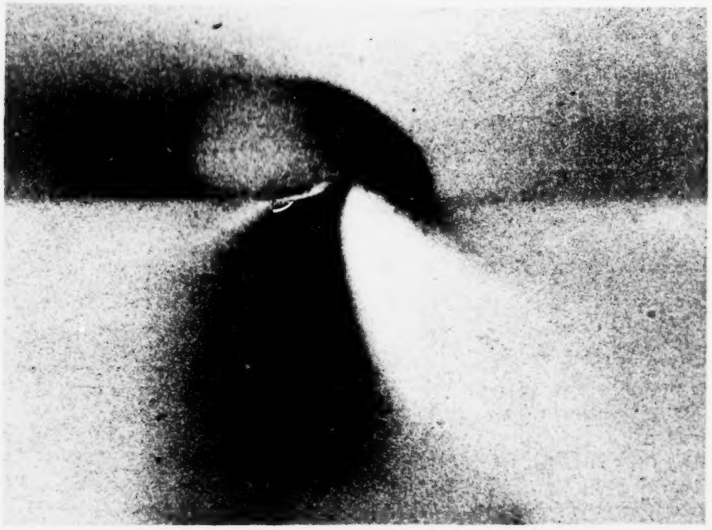
TEST

b.

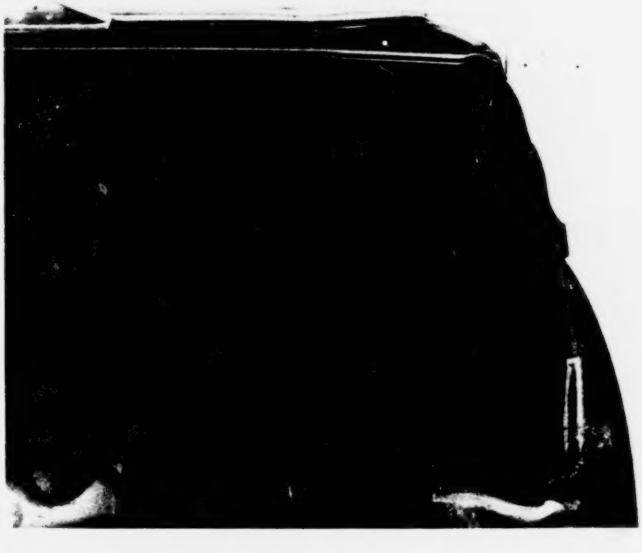


c.

TEST

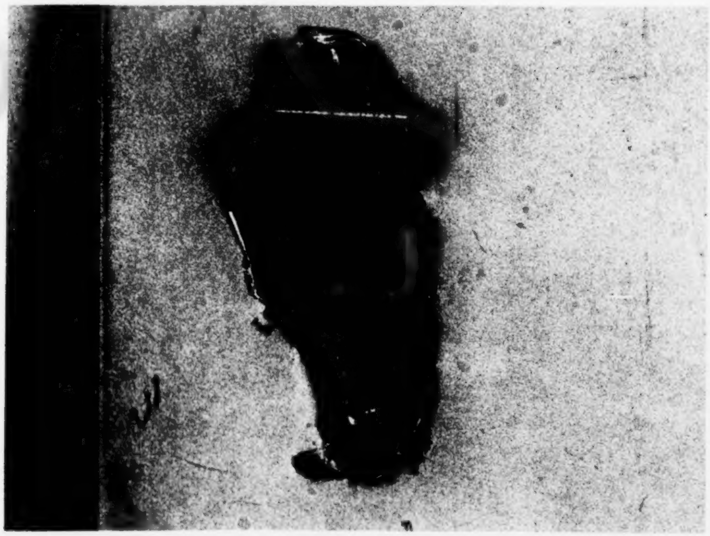


d. ____

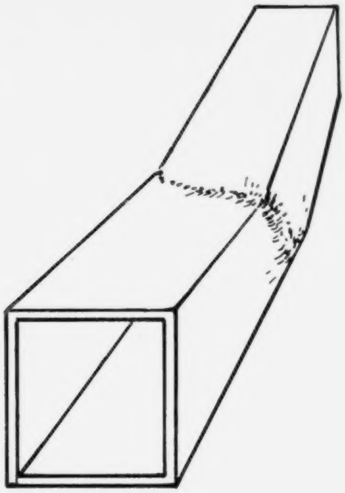


e. ____

TEST



f. ____



g. ____

TEST

h. ______________________________

9. List five basic metal-straightening methods.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

10. Match basic metal-straightening methods to their correct applications. Write the correct numbers in the blanks. Methods and applications continued on next page.

______a. Used for repair of metal damage that is not severe; often used on any remaining high or low spots after power jack or panel puller has been used

______b. Used to pull out low-crown dents where there is no buckled metal

______c. Used to pry out metal damage that is accessible from behind

______d. Used to shrink metal that has stretched too far

1. Vacuum cups
2. Power jack and body-pulling equipment
3. Finishing pick (pry pick)
4. Hammer and dolly
5. Slide hammer

TEST

_____e. Used on high-crown or eyebrow dents to return metal to its original contour without creating hammer marks

_____f. Used to prepare stretched metal for body filler without actually shrinking or straightening the metal

_____g. Used to rough out or align large wrinkled or collapsed damage by either pushing or pulling metal back to its proper shape and dimensions

_____h. Used to pull back to proper contour boxed section metal or metal inaccessible from behind

_____i. Used to pull out dents and to relieve pressure around outside of metal damage that is inaccessible from behind

_____j. Used to return to its original contour shallow metal damage that is accessible from behind

6. Heat shrinking
7. Cold shrinking (kinking)
8. Bumping spoon and hammer
9. Pull tabs and rods
10. Slapping spoon and dolly

11. State eight guidelines for use and care of hydraulic rams and power jacks.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

12. Arrange in order the basic steps in repairing extensive metal damage. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Relieve pressure of indirect damage, working from outer edge of damage area toward center of damage area

_____b. Shrink if necessary

_____c. Relieve pressure of direct damage in same direction and manner that it went in

_____d. Rough out direct impact point

TEST

13. Discuss clues to determining direction of damage.

    a. Rolled buckles — ____________________

    ____

    ____

    b. Direct damage marks — ____________________

    ____

    c. Pressure forces — ____________________

    ____

(NOTE: Test question 14 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

14. Demonstrate the ability to

    a. Use hammer and dolly to rough out a panel.

    b. Use bumping or slapping spoon to rough out a panel.

    c. Use pull rods or slide hammer to rough out a panel.

    d. Use pry picks or body spoon to rough out a panel.

    e. Use vacuum cups to rough out a panel.

    f. Use pull tabs to rough out a panel.

    g. Use hydraulic ram and power jack to rough out a panel.

    h. Align a hood.

    i. Align a fender.

    j. Align a door.

    k. Align a deck lid and check for proper seal.

    l. Inspect, test, and align a hydraulic impact-absorbing bumper.

ROUGHOUT
UNIT II

ANSWERS TO TEST

1. a. 2
   b. 8
   c. 5
   d. 1
   e. 3
   f. 4
   g. 6
   h. 9
   i. 7

2. a. 4
   b. 1
   c. 5
   d. 3
   e. 2

3. To help set dimensions and proper clearances (gaps) for repair of body panels and installation of outer body panels

4. a. Car frame
   b. Impact-absorbing unit
   c. Stone deflector or sight shield
   d. Vinyl sight shield cap
   e. Support bar
   f. Face bar
   g. Hydraulic fluid reservoir
   h. Return spring
   i. Piston
   j. Valve
   k. Inner cylinder

5. Answer should include any six of the following

   a. Be safe; wear approved eye protection at all times
   b. Stand clear of bumper at all times
   c. Do not apply heat to unit
   d. Do not weld in area of unit
   e. Do not attempt to repair a damaged unit; always replace it with a new unit
   f. When only *one* energy absorber is being replaced, support that end of bumper so that it will not fall when absorber is removed
   g. If unit is bound up so that it cannot extend, attach a chain or cable to bumper to prevent it from flying forward if pressure is suddenly released
   h. Relieve pressure *before* removing unit from vehicle
   i. Relieve pressure *before* scrapping or disposing of a unit

6. a. Type
   b. Shape
   c. Thickness (gauge)

ANSWERS TO TEST

7. Description should include the following
    - a. Outer surface becomes stretched
    - b. Center remains the same
    - c. Inner surface is upset (compressed and thicker)

8.
    - a. Eyebrow
    - b. Buckle
    - c. Rolled buckle
    - d. Hinge
    - e. Compression or wrinkle
    - f. Tear or gouge
    - g. Collapsed box section
    - h. Gouge

9. Answer should include any five of the following
    - a. Hammer and dolly
    - b. Slide hammer
    - c. Power jack and body-pulling equipment
    - d. Pull tabs and rods
    - e. Vacuum cups
    - f. Finishing pick (pry pick)
    - g. Heat shrinking (or heating to remove work hardening)
    - h. Cold shrinking (kinking)
    - i. Bumping spoon and hammer
    - j. Slapping spoon and dolly

10.
    - a. 4
    - b. 1
    - c. 3
    - d. 6
    - e. 8
    - f. 7
    - g. 2
    - h. 9
    - i. 5
    - j. 10

11. Answer should include any eight of the following
    - a. Choose ram of right capacity for job
    - b. Do not overextend ram
    - c. Do not tamper with spring-retaining screw at bottom of ram
    - d. Use the proper attachments, and protect all threads by screwing attachments on completely
    - e. Keep oil lines clean at all times
    - f. Prevent dirt and other foreign matter from entering hydraulic system by installing dust caps on coupler halves when not connected to jack pump
    - g. When using attachments where load is off center, stop frequently to adjust load to a less off-center position
    - h. Take care not to drop heavy or sharp objects on hydraulic hose as this could cause the hose to fray or kink
    - i. Allow enough clearance for hydraulic hose and coupler so that no pressure will be exerted on them by the work
    - j. Avoid heating up of hydraulic equipment when using oxyacetylene torch
    - k. When refilling hydraulic jack with oil, first collapse ram if it is connected to jack pump, and then place pump in vice before adding hydraulic oil to proper level

ANSWERS TO TEST

12. a. 2
    b. 4
    c. 1
    d. 3

13. Discussion should include the following

    a. Rolled buckles — Move away from point of first contact; when there are two or three, they converge (like spokes of a wheel to a hub) at point of first contact
    b. Direct damage marks — Direction of damage always ends at mark created by impact object
    c. Pressure forces — Side of greatest pressure shift of metal indicates which way the metal traveled

14. Performance skills evaluated to the satisfaction of the instructor

METAL FINISHING
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to select correct abrasives and use correct grinding and sanding methods to finish steel and aluminum vehicle panels. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with metal finishing.
2. Identify basic polishing techniques used in metal finishing.
3. State the correct angle of disc contact with metal.
4. Match to their correct applications types of grinders used in metal finishing.
5. State general safety rules for using grinders.
6. Select from a list guidelines for safe and proper grinding techniques.
7. Match common grit sizes to their correct applications.
8. Identify recommended grinding speeds for common grinding disc diameters.
9. Match to their correct definitions terms associated with abrasives.
10. Select from a list guidelines for use and care of abrasives.
11. Demonstrate the ability to
    a. Remove surface rust.
    b. Prepare a steel panel for body filler.
    c. Prepare an aluminum panel for body filler.
    d. Remove scratches and polish a metal surface.

METAL FINISHING
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Supplement #1 — Abrasive Papers

   D. Transparency masters

      1. Transparency #1 — Correct Disc Angle

      2. Transparency #2 — Buffing

      3. Transparency #3 — Crosscutting

   E. Information sheet

   F. Job sheets

      1. Job Sheet #1 — Remove Surface Rust

      2. Job Sheet #2 — Prepare a Steel Panel for Body Filler

      3. Job Sheet #3 — Prepare an Aluminum Panel for Body Filler

      4. Job Sheet #4 — Remove Scratches and Polish a Metal Surface

   G. Test

   H. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials to supplement unit.

      1. Filmstrips

         (NOTE: Filmstrips *a* and *b* on the next page are available from Teaching Aids Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321. Each filmstrip deals with complete metal finishing techniques using hammers, files, dollies, and grinders.)

SUGGESTED ACTIVITIES

   a. *Auto Body: Metal Finishing*

   b. *Metal Finishing*

   c. *Using Portable Grinders Safely*

   d. *Portable Grinder Attachments and Grinding*

   e. *Basic Autobody Repair: Unit 2*, available from Career Aids, Incorporated, 20417 Nordhoff Street, Department R, Chatsworth, California 91311; phone 818-341-8200

      (NOTE: This filmstrip covers hand abrasives, board file and power tool abrasives, and sandblasting.)

   f. *Auto Body Repair: Metal Work*, "Hand Tools and Power Equipment," available from Prentice-Hall Media, ServCode DU, White Plains Road, Tarrytown, New York 10591

      (NOTE: This filmstrip module includes segments on disc sanding, body file, cheese grater, and sanding board.)

2. Videocassettes (VHS or Beta 1 & 2)

   a. *Auto Body Series II: Choosing Proper Abrasives*

   b. *Auto Body Series II: Sanding Techniques*

   c. *Auto Body Series II: Sanding Methods*

   (NOTE: These videocassettes are available from Teaching Aids Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321.)

3. Equipment and materials for job sheet procedures

4. Various abrasive papers and discs

5. Examples of various types of grinders

6. Disc cutter

7. Transparencies and competency profiles

   (NOTE: The transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

SUGGESTED ACTIVITIES

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Explain that quality metal finishing is a skill that is acquired after much practice and through careful application of basic grinding and sanding techniques.
- Explain that auto-body technicians skilled in metal finishing techniques are sought after by employers in the field.
- Discuss unit and specific objectives, explaining the importance of the specific objectives in providing basic knowledge for accomplishing the unit objective.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with metal finishing.

   SUGGESTIONS:

   - Demonstrate grinding, sanding, and polishing processes.
   - Show students examples of grinding discs and backing pads. Demonstrate how to attach pads and discs to grinders.
   - Show students how to use a disc cutter and then allow each student to use the cutter to cut a disc to size.
   - Show students examples of sand scratches caused by poor metal finishing techniques. Discuss ways to avoid such scratches.

2. Use Information Sheet, Section II to introduce students to the basic polishing techniques used in metal finishing and to the correct angle of disc contact with metal.

   SUGGESTIONS:

   - Use Transparencies #1 through #3 to illustrate your discussion.
   - Demonstrate the correct angle of disc contact, and then have each student practice achieving such contact.
   - Demonstrate buffing and crosscutting techniques. Allow students to practice buffing and crosscutting techniques until they are proficient.

SUGGESTED ACTIVITIES

3. Use Information Sheet, Section IV to discuss applications for the various types of grinders used in metal finishing.

   SUGGESTIONS:

   - Show students examples of each type of grinder listed in this section of the information sheet.
   - Explain that grinders are often chosen merely because of the technician's personal preference, but that grinders are also chosen because of their speeds and versatility. Explain also that the type of metal and the type of damage also dictate which abrasive is needed and, therefore, which grinder or sander is needed.
   - Demonstrate the application of each type of grinder, and discuss the advantages and disadvantages of each.
   - Discuss the use of pneumatic versus electric grinders and sanders.

4. Use Information Sheet, Sections V and VI to discuss general safety rules for using power grinders and guidelines for safe and proper grinding techniques.

   SUGGESTIONS:

   - Set a good example for your students by wearing all protective clothing and eye and face protection when demonstrating the techniques involved in metal finishing.
   - Relate case studies or examples from past experience in which technicians were injured because of carelessness or failure to comply with basic safety rules.
   - Explain the hazards behind each safety rule, i.e., why safety guards should not be removed; why recommended grinding speeds should not be exceeded, why electric sanders should not be run in or near water.
   - Demonstrate what happens when the grinder is held too loosely at the wrong angle to the work surface, and what happens when the technician grinds too close to trim or projections. In other words, demonstrate the consequences of not following the guidelines for safe and proper grinding techniques.

5. Use Information Sheet, Section VII to explain basic applications for common grit sizes.

   SUGGESTIONS:

   - Show students examples of the various grit sizes and discuss possible applications for each.

SUGGESTED ACTIVITIES

- Distribute copies of Supplement #1 to the students for future reference.

6. Use Information Sheet, Section VIII to discuss recommended speeds for common grinding disc diameters.

   SUGGESTION:

   - Explain the consequences of exceeding recommended speeds.

7. Use Information Sheet, Section IX to introduce terms associated with abrasives.

   SUGGESTIONS:

   - Show students examples of production and finish papers.
   - Show students various backings used for abrasives. Explain the advantages and disadvantages of each type of backing.
   - Show students open-coat and closed-coat abrasives. Demonstrate each to illustrate their clogging properties.
   - Discuss backing weights and A, C, D designations. Explain the purposes of the different weights.

8. Use Information Sheet, Section X to discuss guidelines for use and care of abrasives.

   SUGGESTIONS:

   - Read to the class or allow the students to read the precautions and instructions on various box labels, discs, or charts for different abrasive products.
   - Show students an example of an abrasive disc or paper that shows excessive wear.
   - Show students examples of abrasives that are curled because of improper storage.

F. Demonstrate and discuss procedures outlined in Job Sheets #1 through #4.

G. Have students complete Job Sheets #1 through #4.

H. Give test.

I. Critique test and discuss in class.

J. Complete appropriate section of competency profiles.

SUGGESTED ACTIVITIES

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*. New York: McGraw-Hill Book Company/Gregg Division, 1980.

B. Duenk, Dr. Lester G., Dr. W. Randolph Williams, and Clarence A. Brooks. *Auto Body Repair*, Peoria, Illinois: Chas. A. Bennett Co., Inc. 1977.

C. Fisher Body Division. *Fundamentals of Body Sheet Metal Repair*. Warren, Michigan: General Motors Corporation, 1969.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

E. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

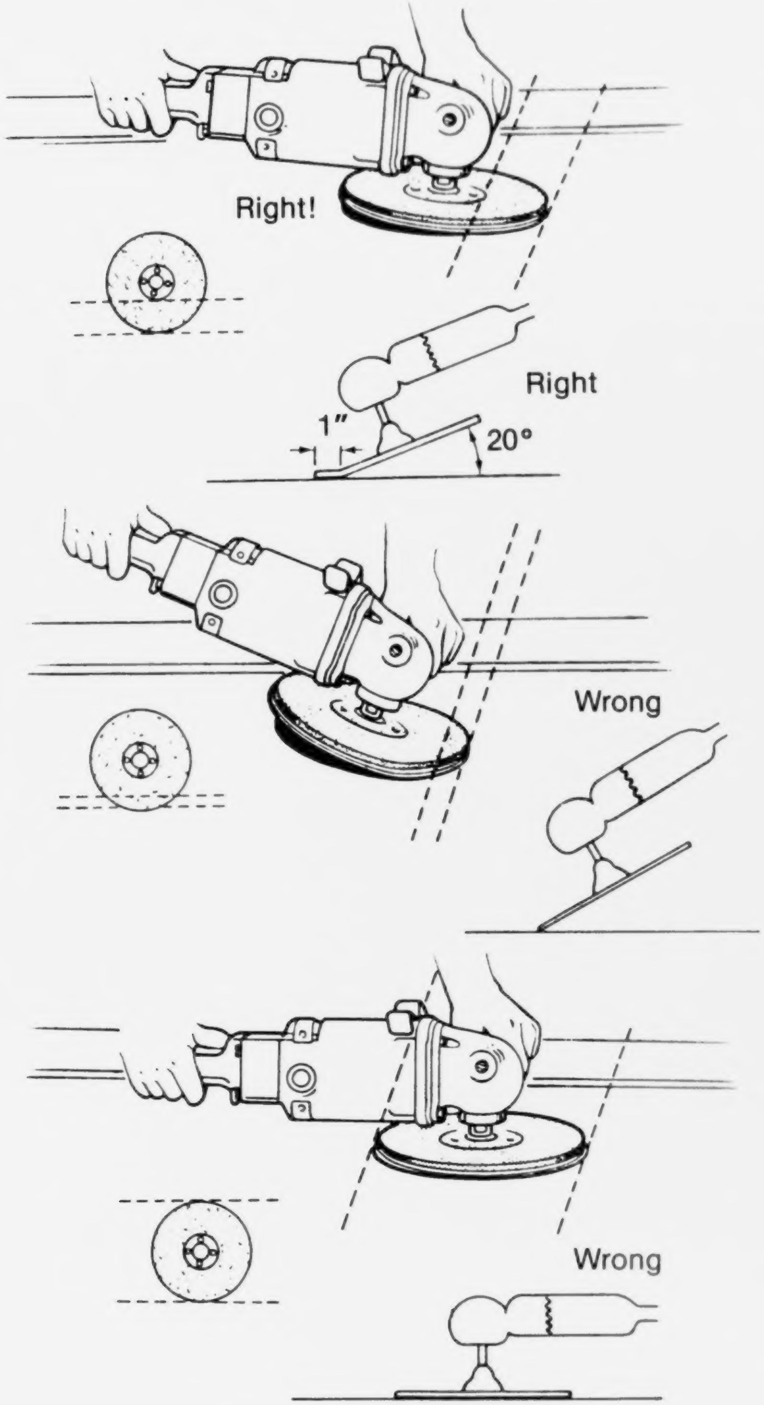
SUGGESTED ACTIVITIES

SUPPLEMENT #1 — ABRASIVE PAPERS

Grinding Disc	Grit #	Primary Use
Very coarse	16 grit	Removal of heavy paint buildup, heavy rust, and weld scale
Coarse	24 grit	Removal of medium paint buildup, light rust, medium filler deposits
Medium	36 grit	Removal of original paint and light rust
Fine	50 grit	Removal of scratches produced by coarse-grit discs on bare metal

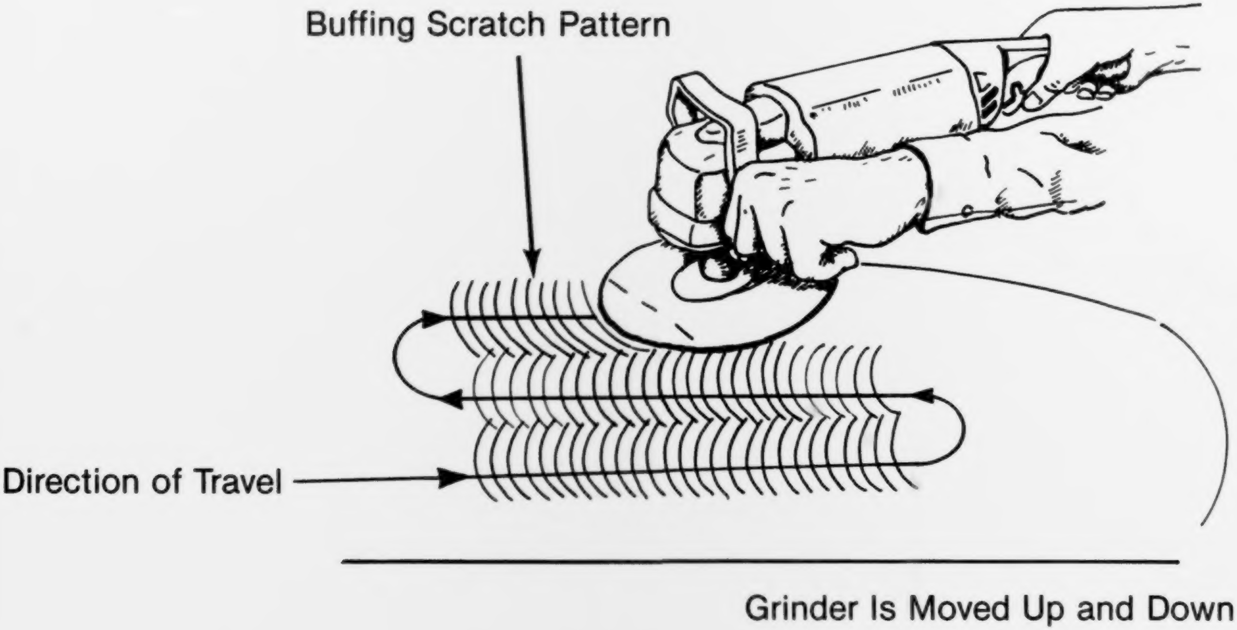
Production Paper	Grit #	Primary Use
Coarse	36 grit	Rough cutting and shaping of body filler
Medium	40 grit	Medium cutting and shaping of body filler
Fine	80 grit	Removal of scratches left in body filler by coarse-grit production papers
Very fine	180 grit	Featheredging broken paint and removing sand scratches

Correct Disc Angle

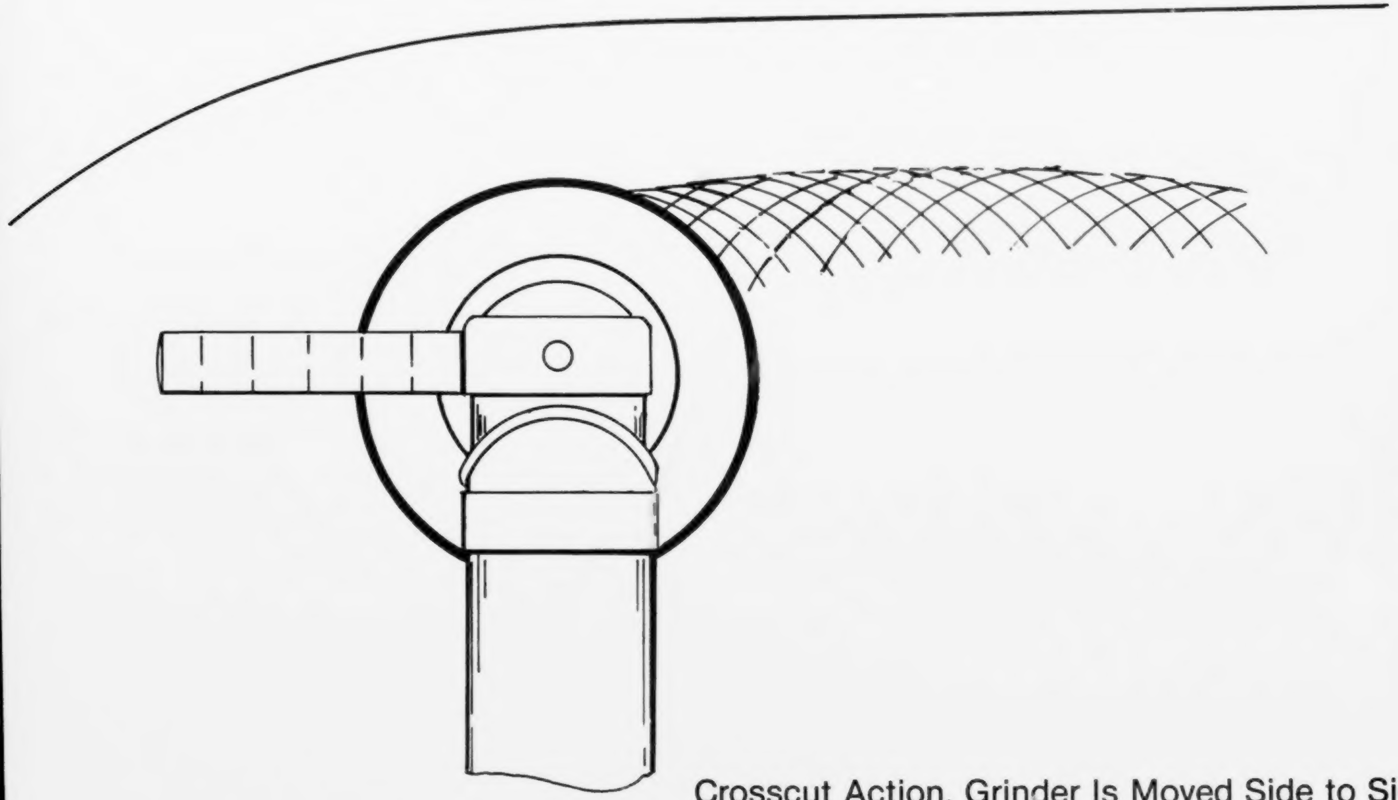


Courtesy of Black & Decker Co., Ltd.

Buffing


Buffing Scratch Pattern
Direction of Travel
Grinder Is Moved Up and Down

Crosscutting



Crosscut Action, Grinder Is Moved Side to Side

METAL FINISHING
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Metal finishing — Process of grinding a metal surface to a smooth, bare finish

B. Grinding — Process of using coarse abrasives on pneumatic or electric grinder at high speeds to remove weld scale, rust scale or deposits, heavy filler applications, or heavy paint deposits

C. Sanding — Process of using fine abrasives on pneumatic or electric sander at low speeds to smooth and finish ground surfaces

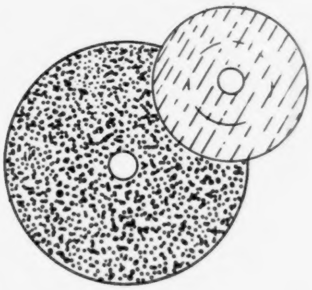
D. Metal polishing — Process of finish sanding with a fine abrasive to obtain a smooth, scratch-free surface after grinding and sanding are complete

E. Crosscut — Pattern abrasive cuts into metal during finishing process

F. Grinding disc — Coarse, durable abrasive grit bonded to stiff backing that is usually round (Figure 1)

EXAMPLE:

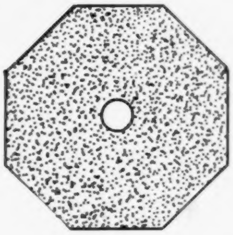
FIGURE 1



(NOTE: Octagonal grinding discs [Figure 2] may be cut from round discs. Octagonal discs are useful for grinding reverse curves and other hard-to-reach areas.)

EXAMPLE: Octagonal disc

FIGURE 2



INFORMATION SHEET

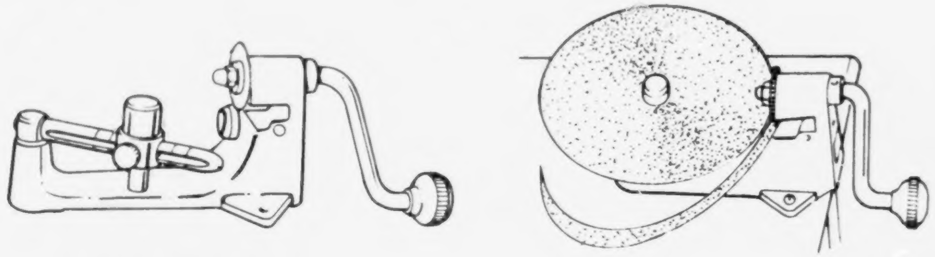
G. Sanding disc — Fine, semidurable abrasive grit bonded to soft backing that is usually round

H. Backing pad — Accessory used to help provide stiffness to abrasive disc

I. Disc cutter — Tool used to trim worn outer edge from grinding disc so that it may used on next smaller sized backing pad (Figure 3)

EXAMPLE:

FIGURE 3



Courtesy of Black & Decker Co., Ltd.

J. Sand scratches — Marks on metal surface; usually caused by poor metal finishing techniques

EXAMPLES: Scratches or gouges caused by improper angle of grinder or coarse grinder discs, poor sanding, or the use of too coarse an abrasive

II. Basic polishing techniques used in metal finishing

A. Buffing — Process of moving grinder up and down, using top portion of disc face

B. Crosscutting — Process of moving grinder from side to side, using top portion of disc face

III. Correct angle of disc contact with metal — From 10 to 20 degrees; at no time should over 1 to 1½ inches of the disc contact the metal

IV. Applications of types of grinders used in metal finishing

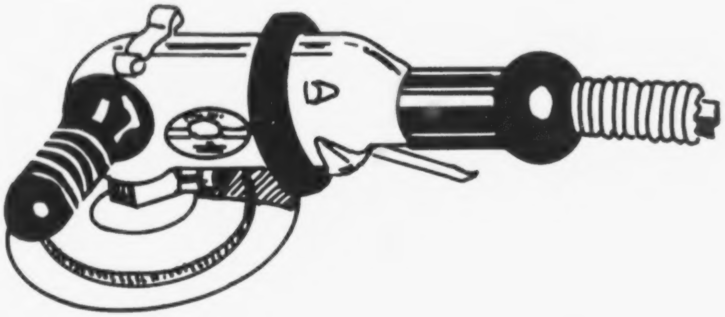
(NOTE: Grinders may be pneumatic [powered by compressed air] or electric [powered by electricity].)

INFORMATION SHEET

A. Disc — Used for grinding small areas of damaged surfaces to prepare surface for finish sanding or application of body filler (Figure 4)

EXAMPLE:

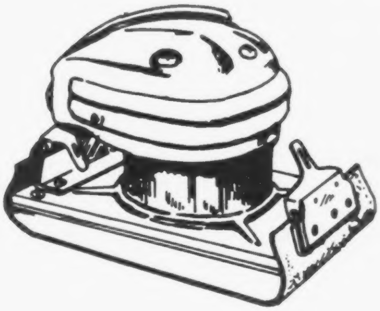
FIGURE 4



B. Orbital — Used for dry sanding of plastic and fiberglass for a smooth, even finish (Figure 5)

EXAMPLE:

FIGURE 5

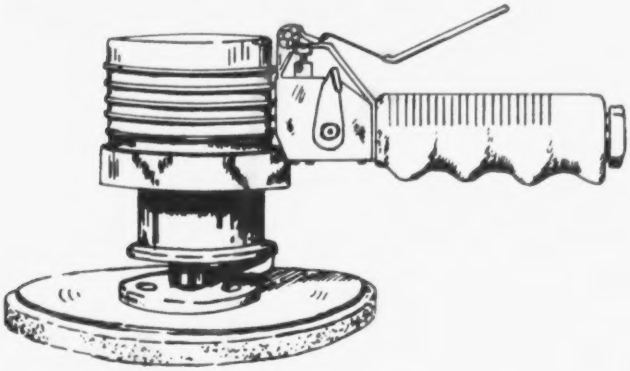


INFORMATION SHEET

C. Oscillating — Used for sanding of metal or paint and for featheredging broken paint edges (Figure 6)

EXAMPLE:

FIGURE 6

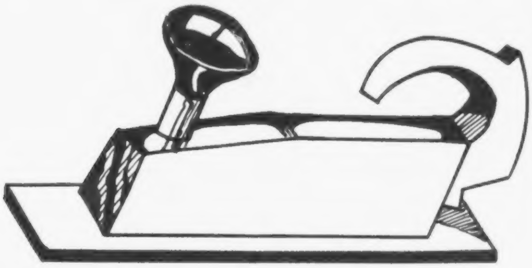


D. Air file — Used mainly for finish sanding of metal or body filler on large, flat surfaces (Figure 7)

(NOTE: The air file may also be called a *reciprocating* or *straightline* grinder.)

EXAMPLE:

FIGURE 7



INFORMATION SHEET

V. General safety rules for using grinders

  A. Wear approved eye protection and a face shield

  B. Wear arm guards, leather gloves, and leather aprons to protect against hot grinding sparks

  (NOTE: In addition to causing burns, sparks can cause loss of control of equipment, thus making protective clothing extra valuable.)

  C. Wear particle mask or respirator to minimize dust inhalation

  D. Never remove safety guards from grinders

  E. Do not run electric grinders in or near water

  F. Run grinders only at speeds or air pressures recommended by manufacturer of tool or accessory

  G. Do not use grinders with nicked, cut, or frayed hoses or cords; use only approved three-wire ground system

  H. Work only in well-ventilated area and avoid breathing dust particles generated by grinding

  I. Never free-run a grinding disc or set grinder down until it stops completely

  J. Be conscious of grinder hose or cord at all times to avoid entanglement

  K. Always disconnect grinder from power source before changing discs or accessories

VI. Guidelines for safe and proper grinding techniques

  A. When disc grinding, hold grinder firmly at a low angle to work surface

  B. Grind to direct dust away from face and toward floor

  C. Avoid grinding too close to trim, bumpers, or any projection that might snag or catch edge of grinding disc

  D. Never start a disc grinder in contact with work surface

  E. Always stop disc grinder in contact with work surface

VII. Basic applications of common grit sizes

  A. #16 grit — Heavy grinding

  B. #24 grit — Medium grinding

  C. #36 grit — Light grinding

  D. #50 grit — Metal polishing

INFORMATION SHEET

VIII. Recommended speeds for common grinding disc diameters

A. 5-inch diameter — Not over 7650 rpm

B. 7-inch diameter — Not over 5500 rpm

C. 9-inch diameter — Not over 4200 rpm

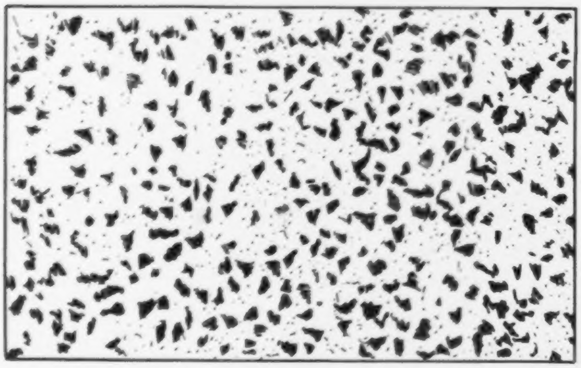
IX. Terms and definitions associated with abrasives

A. Open coat — Type of abrasive surface in which abrasive particles are separated with some space between them; mineral covers 50 to 70 percent of backing surface (Figure 8)

(NOTE: Open-coat abrasives are used for rough sanding and grinding to remove old paint and rust and to cut down solder or welds. Because the surface of this abrasive is "open," it does not get plugged with the material being removed.)

EXAMPLE:

FIGURE 8



B. Closed coat — Type of abrasive surface in which abrasive particles have no space between them and completely cover backing; mineral covers 100 percent of backing surface (See Figure 9)

(NOTE: Closed-coat abrasives are used for finishing and polishing after rough grinding or sanding. Because the surface of this abrasive is closed, closed-coat abrasives can get plugged with the material being removed.)

INFORMATION SHEET

EXAMPLE:

FIGURE 9

C. Backing — Paper, cloth, or fiber to which abrasive is bonded

D. Make coat — Coating used to adhere proper amount of minerals to backing

E. Size coat — Coating applied over minerals to firmly bond particles to backing

F. Glue-on-glue coating — Nonwaterproof coating used on finish papers

G. Resin-over-resin coating — Waterproof coating used on wet-or-dry papers

H. Sizing — Reference to number of minerals per square inch

I. Zinc sterate — White powder coating used on finish papers to eliminate clogging

J. Aluminum oxide — Mineral used on production papers

K. Silicon carbide — Mineral used on finish papers

L. A, C, or D designations — Symbols used to indicate backing weight

EXAMPLES: A — Lightweight backing used for finish papers

C — Medium-weight backing used for production papers and for 150 finish papers

D — Heavyweight fiber backing used for grinder discs

INFORMATION SHEET

X. Guidelines for care and use of abrasives

   A. Read and follow all precautions and instructions on box labels, discs, and charts

   B. Do not use abrasive paper or disc if edges show excessive wear, nicks, or tears

   C. Make sure that back-up pads are designed for the work and are free of cuts or nicks at edge or center hole

   D. Seat fiber abrasives flat against back-up pad and never allow abrasive to overhang pad more than 1/4 inch

   E. Store abrasive discs or papers at 65°F to 75°F to prevent excessive curling

   F. Do not use curled abrasive papers or discs until shape is corrected

   G. Do not use dry sandpapers with water

METAL FINISHING
UNIT III

JOB SHEET #1 — REMOVE SURFACE RUST

I. Equipment and materials

   A. Pneumatic or electric grinder

   B. Appropriate abrasives

   C. Rubber-tipped, pneumatic blow gun

   D. Air compressor

   E. Metal cleaner and conversion coating system

   F. Rubber gloves

   G. Leather gloves

   H. Eye protection

   I. Particle mask and face shield

   J. White shop towels

   K. Masking tape

   L. Spray bottle

II. Procedure

   A. Protect with masking tape any moldings, glass, upholstery, or undamaged painted area adjacent to repair

   (NOTE: Masking adjacent areas helps prevent damage due to accidental creeping of the grinder or sander.)

   B. Put on eye protection, particle mask, face shield, and leather gloves

   C. Evaluate rusted area and choose appropriate abrasive from Table 1 below

TABLE 1

Grit	Application
#16	Heavy paint build-up, heavy filler deposits, heavy rust, weld scale
#24	Medium paint build-up, light rust, medium filler deposits
#36	Original paint removal, light rust
#50	Removal of scratches left by coarse grinding disc

JOB SHEET #1

D. Attach grinding disc to grinder and connect grinder to power source

E. Grind rusted area until all rust is removed

F. Turn off grinder and disconnect from power source

G. Attach 50-grit abrasive to grinder and connect grinder to power source

H. Polish rusted area to remove scratches

I. Turn off grinder and disconnect from power source

J. Connect blow gun to air compressor and use to remove any dust or particles from damaged surface

> **CAUTION**
>
> Do not use compressed air to clean yourself or your clothing. The air force is powerful enough to put out an eye.

K. Turn off blow gun and disconnect from air compressor

L. Remove leather gloves and put on rubber gloves

M. Pour metal cleaner into spray bottle, and spray on bare metal surface, following label instructions and cautions

> **CAUTION**
>
> Metal cleaner is a caustic solution that contains acids. Wear rubber gloves to apply it, and avoid skin contact and inhalation of vapors.

N. Wipe off metal cleaner with clean, white towel

O. Spray conversion coating solution on bare metal surface

(NOTE: Conversion coating helps prevent rust from reforming, and helps improve the adhesion of the primer. This step may not be necessary with some metal cleaners. Read the label and follow the label instructions on the product you are using.)

P. Clean work area and return equipment and materials to proper storage

METAL FINISHING
UNIT III

JOB SHEET #2 — PREPARE STEEL PANEL FOR BODY FILLER

I. Equipment and materials

   A. Pneumatic or electric grinder

   B. Appropriate abrasives

   C. Rubber-tipped, pneumatic blow gun

   D. Air compressor

   E. Masking tape

   F. Leather gloves

   G. Particle mask

   H. Face shield

   I. Eye protection

II. Procedure

   A. Protect with masking tape any adjacent moldings, glass, or undamaged painted area

   (NOTE: Masking adjacent areas helps prevent damage due to accidental creeping of grinder.)

   B. Use Table 2 below to choose appropriate abrasive for area to be finished

TABLE 2

Grit	Application
#16	Heavy paint build-up, heavy filler deposits, heavy rust, weld scale
#24	Medium paint build-up, light rust, medium filler deposits
#36	Original paint removal, light rust
#50	Removal of scratches left by coarse grinding disc

JOB SHEET #2

C. Put on eye protection, particle mask, face shield, and leather gloves

D. Using appropriate method, grind roughed-out area 2 to 3 inches beyond damage in all directions

(NOTE: The method used depends upon the shape of the panel.)

E. Turn off grinder, disconnect from power source, and attach 50-grit abrasive

F. Reconnect grinder to power source

G. Polish entire area completely, using crosscut or buffing technique to remove deep scratches left by coarse-grit abrasive

H. Disconnect grinder from power source and remove abrasive disc

I. Connect blow gun to air compressor and use it to clean any remaining dust or particles from surface of damaged area

CAUTION

Do not use compressed air to clean yourself or your clothing. The air force is powerful enough to put out an eye.

J. Turn off blow gun and disconnect from compressor

K. Clean work area and return equipment and materials to proper storage

METAL FINISHING
UNIT III

JOB SHEET #3 — PREPARE AN ALUMINUM PANEL FOR BODY FILLER

I. Equipment and materials

   A. Pneumatic grinder with variable speed control

   (NOTE: It is recommended that a pneumatic grinder with variable speed control be used so that the speed may be adjusted for the aluminum panel.)

   B. Appropriate abrasives

   (NOTE: Aluminum is softer than steel and heats up more quickly. Care must be taken to select a finer-grit disc than that used on steel and to use a slower-speed grinder.)

   C. Rubber-tipped, pneumatic blow gun

   D. Air compressor

   E. Masking tape

   F. Leather gloves

   G. Particle mask

   H. Face shield

   I. Eye protection

II. Procedure

   A. Protect with masking tape any adjacent moldings, glass, or undamaged painted area

   (NOTE: Masking adjacent areas helps prevent damage due to accidental creeping of grinder.)

   B. Choose proper grinding disc for area to be finished

   C. Put on eye protection, particle mask, face shield, and rubber gloves

   D. Attach disc to grinder and connect grinder to power source

   E. Grind metal, using proper technique and being careful not to gouge or overheat the metal while removing paint

JOB SHEET #3

F. Disconnect grinder from power source, remove coarse disc, and attach appropriate fine-grit, closed-coat disc

G. Reconnect grinder to power source

H. Polish the aluminum, using light pressure, a slow speed, and appropriate cross-cutting or buffing technique

I. Disconnect grinder from power source

J. Connect blow gun to power source and use it to clean any remaining dust or particles from surface of damaged area

> **CAUTION**
>
> Do not use compressed air to clean yourself or your clothing. The air force is powerful enough to put out an eye.

K. Disconnect air gun from power source

L. Clean work area and return equipment and materials to proper storage

METAL FINISHING
UNIT III

JOB SHEET #4 — REMOVE SCRATCHES AND FINISH A METAL SURFACE

I. Equipment and materials

  A. Pneumatic or electric grinder

  B. Oscillating sander

  C. Appropriate grinding disc

  D. Appropriate sanding discs

  E. Rubber-tipped, pneumatic blow gun

  F. Air compressor

  G. Masking tape

  H. Leather gloves

  I. Particle mask

  J. Face shield

  K. Eye protection

II. Procedure

  A. Protect with masking tape any moldings, glass, or undamaged painted area adjacent to repair

  (NOTE: Masking adjacent areas helps to prevent damage due to accidental creeping of grinder.)

  B. Analyze scratches to determine suitable method of repair

  (NOTE: If scratches are deep, you may have to grind the metal with the grinder and fine-grit disc. If the scratches are shallow, this process may not be necessary.)

  C. Install appropriate abrasive disc on grinder

  D. Put on eye protection, leather gloves, particle mask, and face shield

  E. Connect grinder to power source

  F. Grind metal, using buffing technique

JOB SHEET #4

G. Disconnect grinder from power source

H. Select medium-grit abrasive to remove scratches left by grinding operation; install abrasive on sander

I. Connect sander to power source

J. Sand surface until all scratches are removed

K. Disconnect sander from power source

L. Select fine-grit abrasive for final smoothing operation and install on sander

M. Reconnect sander to power source

N. Polish metal until surface is smooth and free of scratches

O. Disconnect sander from power source and remove abrasive

P. Connect blow gun to compressor and use to clean any remaining dust or particles from surface of damaged area

CAUTION

Do not use compressed air to clean yourself or your clothing. The air force is powerful enough to put out an eye.

Q. Disconnect blow gun from power source

R. Check surface for scratches and repeat steps L through Q if necessary

S. Clean work area and return equipment and materials to proper storage

METAL FINISHING
UNIT III

TEST

NAME ____ SCORE ________________

1. Match to their correct definitions terms associated with metal finishing. Write the correct numbers in the blanks.

______a. Process of using coarse abrasives on pneumatic or electric grinder at high speeds to remove weld scale, rust scale or deposits, heavy filler applications, or heavy paint deposits

______b. Process of using fine abrasives on pneumatic or electric sander at low speeds to smooth and finish ground surfaces

______c. Process of grinding a metal surface to a smooth, bare finish

______d. Process of finish sanding with a fine abrasive to obtain a smooth, scratch-free surface after grinding and sanding are complete

______e. Marks on metal surface; usually caused by poor metal finishing techniques

______f. Tool used to trim worn outer edge from grinding or sanding disc so that it may be used on next smaller sized backing pad

______g. Accessory used to help provide stiffness to abrasive disc

______h. Coarse, durable abrasive grit bonded to stiff backing that is usually round

______i. Fine, semidurable abrasive grit bonded to soft backing that is usually round

______j. Pattern abrasive cuts into metal during finishing process

1. Grinding disc
2. Sanding disc
3. Sand scratches
4. Crosscut
5. Metal finishing
6. Grinding
7. Metal polishing
8. Sanding
9. Disc cutter
10. Backing pad

2. Identify basic polishing techniques used in metal finishing. Write the correct names in the blanks.

Buffing **Crosscutting**

______________a. Process of moving grinder from side to side, using top portion of disc face

______________b. Process of moving grinder up and down, using top portion of disc face

TEST

3. State the correct angle of disc contact with metal.

____

____

4. Match to their correct applications types of grinders used in metal finishing. Write the correct numbers in the blanks.

______a. Used for grinding small areas of damaged surfaces to prepare surface for finish sanding or application of body filler

______b. Used for dry sanding of plastic and fiberglass for a smooth, even finish

______c. Used mainly for finish sanding of metal or body filler on large, flat surfaces

______d. Used for sanding of metal or paint and for featheredging broken paint edges

1. Air file
2. Orbital
3. Disc
4. Oscillating

5. State general safety rules for using grinders. Write the correct words in the blanks.

a. Wear approved ____________ ____________ and a ____________ ____________

b. Wear ____________ guards, ____________ gloves, and leather aprons to protect against hot ____________ ____________

c. Wear ____________ ____________ or ____________ to minimize dust inhalation

d. Never remove ____________ ____________ from grinders

e. Do not run ____________ grinders in or near water

f. Run grinders only at ____________ or ____________ ____________ recommended by manufacturer of tool or accessory

g. Do not use grinders with ____________ , ____________ , or ____________ hoses or cords; use only approved ____________ - ____________ ground system

TEST

h. Work only in ____________ - ____________ area and avoid breathing ____________ ____________ generated by grinding

i. Never ____________ ____________ a grinding disc or set grinder down until it ____________ ____________

j. Be conscious of grinder ____________ or ____________ at all times to avoid entanglement

k. Always ____________ grinder from power source before changing discs or accessories

6. Select from the following list guidelines for safe and proper grinding techniques. Write an "X" in the blank before each correct answer.

_____a. When disc grinding, hold grinder firmly and at a 90-degree angle to work surface

_____b. Grind to direct dust away from face and toward floor

_____c. Grind close to trim, bumpers, or any projection to avoid snagging or catching edge of grinding disc

_____d. Never start a disc grinder in contact with work surface

_____e. Never stop a disc grinder in contact with work surface

7. Match common grit sizes to their correct applications. Write the correct numbers in the blanks.

_____a. Heavy grinding — 1. #50 grit

_____b. Metal polishing — 2. #36 grit

_____c. Medium grinding — 3. #24 grit

_____d. Light grinding — 4. #16 grit

8. Identify recommended grinding speeds for common grinding disc diameters. Write the correct speeds in the blanks.

________________________a. 5-inch diameter

________________________b. 7-inch diameter

________________________c. 9-inch diameter

TEST

9. Match to their correct definitions terms associated with abrasives. Write the correct numbers in the blanks.

______a. Mineral used on finish papers

______b. Mineral used on production papers

______c. White powder coating used on finish papers to eliminate clogging

______d. Paper, cloth, or fiber to which abrasive is bonded

______e. Coating applied over minerals to firmly bond particles to backing

______f. Coating used to adhere proper amount of minerals to backing

______g. Nonwaterproof coating used on finish papers

______h. Waterproof coating used on wet-or-dry papers

______i. Reference to number of minerals per square inch

______j. Symbols used to indicate backing weight

______k. Type of abrasive surface in which abrasive particles have no space between them and completely cover backing; mineral covers 100 percent of backing surface

______l. Type of abrasive surface in which abrasive particles are separated with some space between them; mineral covers 50 to 70 percent of backing surface

1. Glue-on-glue coating
2. Backing
3. A, C, or D designations
4. Aluminum oxide
5. Silicon carbide
6. Zinc sterate
7. Make coat
8. Size coat
9. Open coat
10. Closed coat
11. Resin-over-resin coating
12. Sizing

10. Select from the following list guidelines for care and use of abrasives. Write an "X" in the blank before each correct answer.

______a. Read and follow all precautions and instructions on box labels, discs, and charts

______b. Do not use abrasive paper or disc if edges show *any* wear

______c. Make sure that back-up pads are designed for the work and are free of cuts or nicks at edge or center hole

______d. Seat fiber abrasives flat against back-up pad, and never allow abrasive to overhang pad more than 1/4 inch

______e. Store abrasive discs or papers at 55°F to 85°F to prevent excessive curling

______f. Do not use curled abrasive papers or discs until shape is corrected

______g. Do not use wet sandpapers with water

TEST

(NOTE: Test item 11 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

11. Demonstrate the ability to

    a. Remove surface rust.

    b. Prepare a steel panel for body filler.

    c. Prepare an aluminum panel for body filler.

    d. Remove scratches and polish a metal surface.

METAL FINISHING
UNIT III

ANSWERS TO TEST

1. a. 6
   b. 8
   c. 5
   d. 7
   e. 3
   f. 9
   g. 10
   h. 1
   i. 2
   j. 4

2. a. Crosscutting
   b. Buffing

3. From 10 to 20 degrees; at no time should over 1 to 1 ½ inches of the disc contact the metal

4. a. 3
   b. 2
   c. 1
   d. 4

5. a. Eye protection, face shield
   b. Arm, leather, grinding sparks
   c. Particle mask, respirator
   d. Safety guards
   e. Electric
   f. Speeds, air pressures
   g. Nicked, cut, frayed; three-wire
   h. Well-ventilated, dust particles
   i. Free-run, stops completely
   j. Hose, cord
   k. Disconnect

6. b, d

7. a. 4
   b. 1
   c. 3
   d. 2

ANSWERS TO TEST

8. a. Not over 7650 rpm
   b. Not over 5500 rpm
   c. Not over 4200 rpm

9. a. 5
   b. 4
   c. 6
   d. 2
   e. 8
   f. 7
   g. 1
   h. 11
   i. 12
   j. 3
   k. 10
   l. 9

10. a, c, d, f

11. Performance skills evaluated to the satisfaction of the instructor

SHRINKING
UNIT IV

UNIT OBJECTIVE

After completing this unit, the student should be able to shrink stretched vehicle metals, using appropriate methods. The student will show this knowledge by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with metal shrinking.
2. State the principles of heat distortion.
3. Select from a list guidelines for heat shrinking sheet metal.
4. List ways in which heat shrinking aluminum differs from heat shrinking steel.
5. Explain reasons for using proper heat when shrinking metal.
6. List guidelines for quenching.
7. Explain why metal is kinked in the cold shrink process.
8. Demonstrate the ability to
    - a. Heat shrink a high spot in a steel panel.
    - b. Heat shrink a gouge in a steel panel.
    - c. Cold shrink a high spot in a sheet-metal panel.
    - d. Heat shrink a high spot in an aluminum panel.

SHRINKING
UNIT IV

SUGGESTED ACTIVITIES

I. Unit contents

  A. Objective sheet

  B. Suggested activities

  C. Transparency masters

    1. TM #1 — Heat Shrinking

    2. TM #2 — Cold Shrinking (Kinking)

    3. TM #3 — Quenching

  D. Information sheet

  E. Job sheets

    1. Job Sheet #1 — Heat Shrink a High Spot in a Steel Panel

    2. Job Sheet #2 — Heat Shrink a Gouge in a Steel Panel

    3. Job Sheet #3 — Cold Shrink a High Spot in a Sheet-Metal Panel

    4. Job Sheet #4 — Heat Shrink a High Spot in an Aluminum Panel

  F. Test

  G. Answers to test

II. Instructor's guide

  A. Review unit and plan presentation.

  B. Order or obtain materials to supplement unit.

    1. Filmstrips

      a. *Shrinking Metal*

      b. *Auto Body: Shrinking Metal*

      (NOTE: These two filmstrips—available from Teaching Aids, Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321—show how to shrink stretched body metal with the use of heat, pressure, and moisture. The use of heat, slappers, hammers, and other tools is explained in filmstrip *b*.)

SUGGESTED ACTIVITIES

2. Equipment and materials for job sheet procedures

3. Aluminum and steel auto-body sheet metal for student practice

4. Transparencies and competency profiles

   (NOTE: The transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Explain to students that learning proper metal-shrinking techniques takes a lot of practice and that the technician skilled in shrinking has learned from observing the reactions to heat of many different auto-body sheet metals.

- Discuss unit and specific objectives.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms and definitions associated with metal shrinking.

   SUGGESTIONS:

   - Use Transparencies #1 through #3 to illustrate your discussion of the terms *heat shrinking, cold shrinking,* and *quenching.*

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss the principles of heat distortion.

   SUGGESTIONS:

   - Explain that a firm understanding of the principles of heat distortion, coupled with practice and experience, leads to the acquisition of skill in metal shrinking.

   - Using a piece of scrap metal, demonstrate what happens when the metal is heated and cooled.

SUGGESTED ACTIVITIES

- Demonstrate how expansion and contraction are controlled by the amount of heat applied to the metal and the size of the area heated. Show students what happens when an area larger than the head of the shrinking hammer is heated and then struck in the center with the hammer.

3. Use Information Sheet, Section III to discuss the guidelines for heat shrinking auto-body sheet metals.

SUGGESTIONS:

- Review safety precautions and proper procedure for setting up oxyacetylene equipment, turning on the torch, lighting the torch, and adjusting to neutral flame.

- Stress the importance of wearing protective clothing and avoiding burns.

- Explain to the students why they must work quickly.

- Demonstrate what happens when a job is begun before all of the equipment and materials are at hand. Heat a small area and then pretend to search for the correct hammer or dolly block while allowing the metal to cool and lose its elastic tension.

- Heat various auto-body sheet metals to demonstrate the correct colors of properly heated metal.

- Have students practice on scrap-metal panels. Supervise closely, showing them how to keep the inner cone of the oxyacetylene flame the proper distance from the metal, how to heat only a small area, how to use the shrinking hammer and dolly block, and so on.

- Demonstrate and then have students complete Job Sheets #1 through #3.

4. Use Information Sheet, Section IV to explain the differences between heat shrinking aluminum and heat shrinking steel.

SUGGESTIONS:

- Heat shrink a piece of aluminum, pointing out the differences in its reaction to heat as compared to the reaction of the steel heated in your previous demonstration.

- To demonstrate that aluminum shrinks more rapidly than does steel, heat comparable areas on a piece of aluminum and a piece of steel and then quench while both pieces of metal are too hot.

SUGGESTED ACTIVITIES

- Demonstrate the proper technique for hammering aluminum to prevent stretching. Show students what happens when aluminum is hammered too hard.

- Allow students to practice shrinking techniques on scrap pieces or panels of aluminum auto-body sheet metal.

- Demonstrate procedure and then have students complete Job Sheet #4.

5. Use Information Sheet, Section V to discuss guidelines for quenching.

SUGGESTIONS:

- Explain when quenching is desirable.

- Demonstrate and explain what happens when a piece of metal is quenched when it is too hot.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest as necessary.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing.* New York: McGraw-Hill Book Company/Gregg Division, 1980.

B. Duenk, Lester G., W. Randolph Williams, and Clarence A. Brooks. *Auto Body Repair.* Peoria, Illinois: Chas. A. Bennett Co., Inc., 1977.

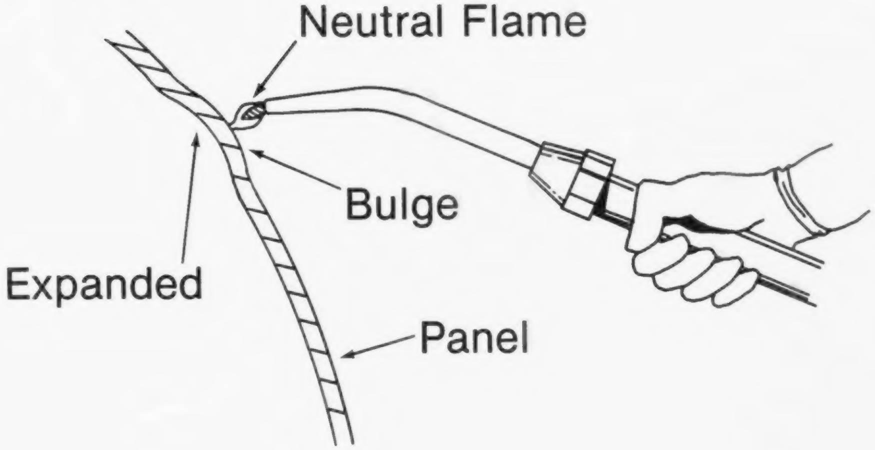
C. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

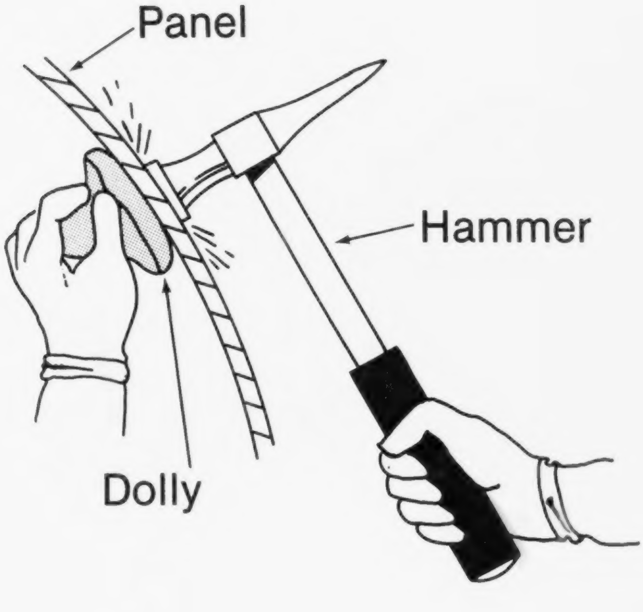
D. Rhone, L.C., and H. David Yates. *Total Auto Body Repair,* 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

E. Richert, Melvin T. *How to Control Auto Body Sheet Metals.* Philadelphia: Chilton Book Company, 1968.

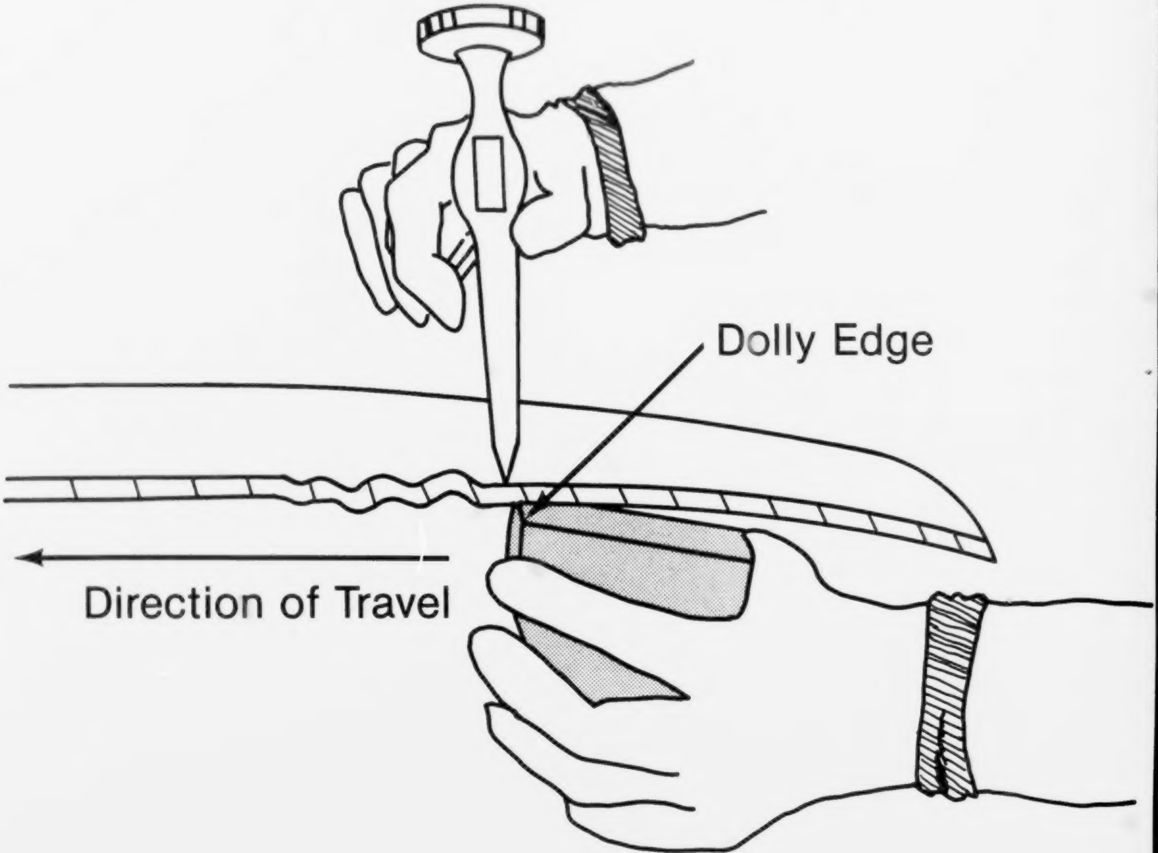
F. Tait, Alex, A.G. Deroche, and N.N. Hildebrand. *The Principles of Autobody Repairing and Repainting.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971.

Heat Shrinking

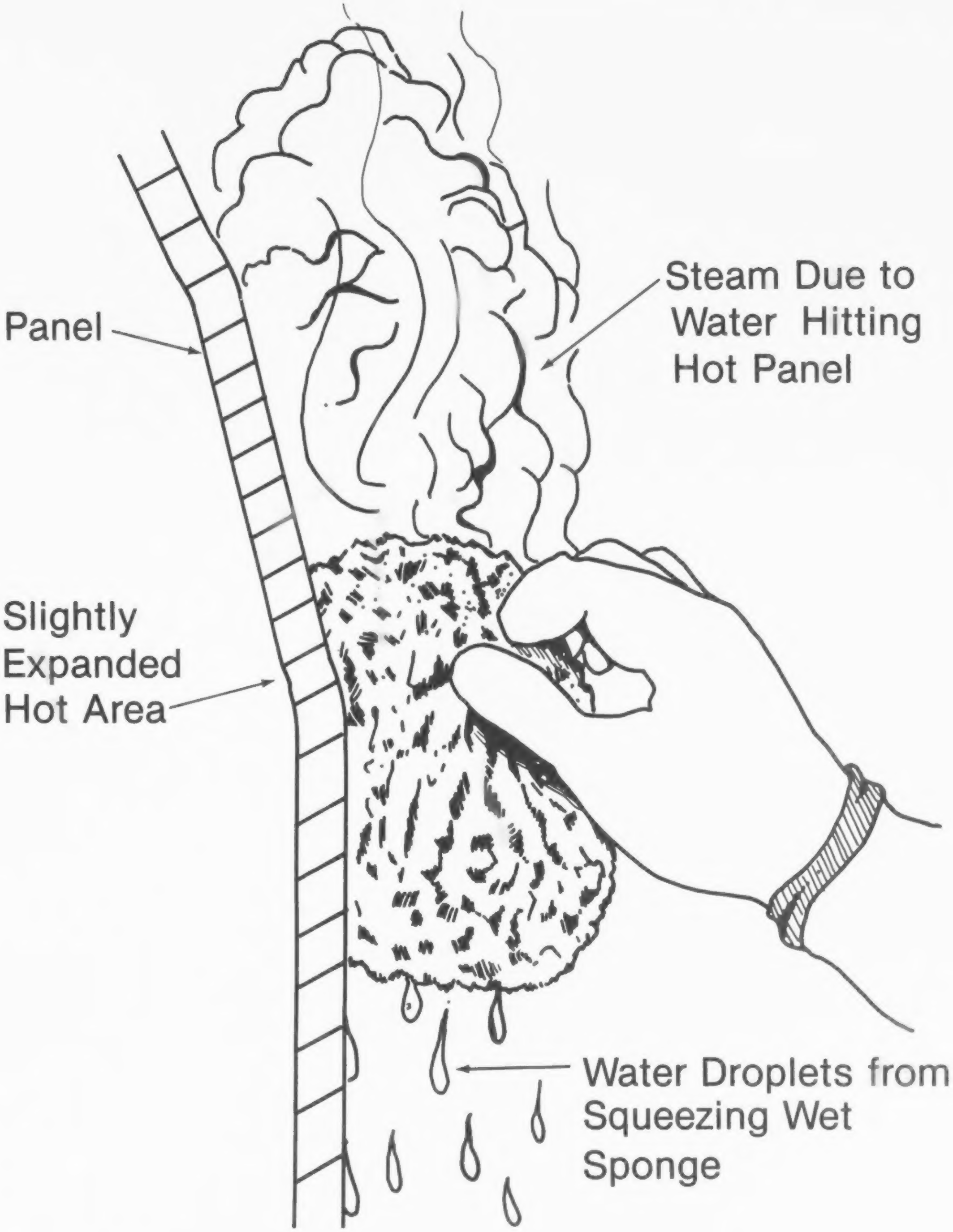




Cold Shrinking (Kinking)



Quenching


Panel
Steam Due to Water Hitting Hot Panel
Slightly Expanded Hot Area
Water Droplets from Squeezing Wet Sponge

SHRINKING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Heat shrinking — Process of heating metal to expand and soften it so that desired upset can be made

   B. Cold shrinking — Process of kinking stretched metal without actually shrinking or stretching it

   C. Overshrinking — Shrinking some of the temporarily expanded metal in addition to that which was stretched

   D. Quenching — Cooling a heated area with water to cause it to shrink

   E. Upset — Compression of metal; opposite of stretch

   F. Stretch — Swelling and thinning of metal; opposite of upset

   G. False stretch — Area in which an upset has caused an adjoining area to bulge so that it appears to be stretched

   H. High spot — Area in which metal is stretched outward

   I. Gouge — Area in which metal is stretched inward

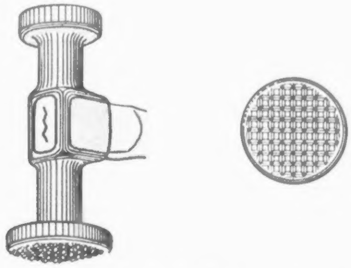
   (NOTE: Gouges are usually caused by collision impact and are generally found in the direct-damage area of a damaged panel.)

   J. Shrinking hammer — Tool with a waffle face that imprints metal on contact, causing metal to be drawn in or shrunk (Figure 1)

   (NOTE: The shrinking hammer is used to help keep the metal from stretching during the metalworking process.)

   EXAMPLE:

FIGURE 1



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INFORMATION SHEET

II. Principles of heat distortion

   A. When heat is applied to metal, the metal expands

   B. As heated metal cools, it contracts (shrinks)

   C. Quickly cooled heated metal contracts more than slowly cooled heated metal

   D. Expansion and contraction of metal are controlled by amount of heat applied and size of area heated

      1. The hotter the area, the more the metal expands and contracts

      2. The larger the heated area, the greater the expansion and the greater the possibility for warpage or distortion

      EXAMPLE: Too much heat applied to a large area of a low-crown panel will result in a wavy and irregular contour (warpage)

III. Guidelines for heat shrinking sheet metal

(NOTE: Practice on scrap-metal panels, and do not be discouraged after your first attempt. The ability to shrink metal properly takes a good deal of practice.)

   A. Be prepared to work quickly

   B. Have on hand all equipment and materials needed before beginning to heat shrink

   EXAMPLES: Oxyacetylene torch and proper welding tips, fire extinguisher, hammer and dolly, bucket of water and sponges

   C. Never heat shrink high-strength steel (HSS) or high-strength, low-alloy steel (HSLA) as heat tends to weaken these metals and could result in metal failure

   D. Keep inner cone of oxyacetylene flame about 1/2 inch from surface of metal

   (NOTE: If the torch cone comes too close to the metal, it could burn a hole in it.)

   E. Generally heat only a small area (no larger than a nickel) at a time

   (NOTE: Sometimes the damaged area may have an oblong or elongated shape. In such cases, heat only a narrow strip of the damaged area.)

   F. Take care not to overheat the metal; heat metal only until it is a cherry red color

   (NOTE: On the newer and thinner metal used for the body panels on today's vehicles, a dull brown rather than cherry red color will often indicate correct heat.)

INFORMATION SHEET

G. Take care to avoid burns when flattening, shaping, or quenching heated metal

H. When hammering heated metal, use dolly with a face of correct curvature for panel being worked on

I. Hit center of heated area with first blow of hammer and then work blows around edge of heated area

IV. Ways in which heat shrinking aluminum differs from heat shrinking steel

A. Aluminum does not respond to heat shrinking as well as does steel

B. Work must be performed much faster than with steel

(NOTE: Aluminum is a good conductor of heat; therefore, the heat spreads to a larger area and may warp the aluminum.)

C. Aluminum does not turn cherry red when heated as does steel

(NOTE: Practice and experience will aid the auto-body technician in determining how much heat to apply to aluminum.)

D. The risk of melting is greater than with steel because aluminum has a lower melting point than steel

E. Quenching shrinks aluminum more quickly than it does steel

F. Hot aluminum must be hammered much more lightly than steel to prevent stretching

V. Reasons for using proper heat when shrinking metal

A. If underheated, metal will not soften and upset cannot occur

B. If overheated, metal at hot spot will collapse and form a depression or hole, or the metal will melt, as in the case of aluminum

C. If properly heated, heat will spread over entire area, providing uniform upset and a smooth surface

VI. Guidelines for quenching

A. Quench when a greater amount of upset is required than when heated metal is allowed to cool slowly

B. Do not quench while metal is extremely hot; wait until metal cools some or turns a blue-black color

INFORMATION SHEET

(NOTE: If the metal is quenched when it is very hot, the steel will become work hardened and will be very difficult to file or sand in preparation for painting. Metal cooled too soon tends to overshrink because the tension set up by cooling affects a greater area than was stretched.)

VII. Why metal is kinked in the cold shrink process

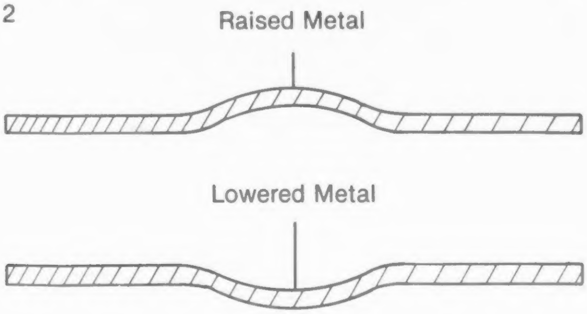
A. Kinking draws in and "shrinks" metal in damaged area

B. Kinking brings damaged metal to acceptable level for body filler

(NOTE: Figure 2 shows what would happen if stretched metal were simply knocked down instead of being kinked. The resulting dished area would be too deep to properly fill with body filler.)

EXAMPLE:

FIGURE 2



SHRINKING
UNIT IV

JOB SHEET #1 — HEAT SHRINK A HIGH SPOT IN A STEEL PANEL

I. Equipment and materials

   A. Shrinking hammer

   B. Dolly block of appropriate contour

   C. Oxyacetylene torch and #0 welding tip

   D. Welding gloves

   E. Full-face shield

   F. Protective clothing

   G. Fire extinguisher

   H. Bucket of water and sponges for quenching

   I. Straightedge

   J. Marker

   K. Cotton glove or cloth

   L. Eye protection

II. Procedure

   A. Determine type of steel used in panel

> **CAUTION**
>
> Never attempt to heat or shrink high-strength steel (HSS) or high-strength, low-alloy steel (HSLA). Heating or shrinking tends to weaken these metals and could cause metal failure.

   B. Determine highest spot in stretched metal by feeling surface of stretched area with a cotton-gloved hand or with a cloth under the hand

   (NOTE: The glove or cloth helps eliminate the friction of your hand on the metal surface and makes it easier to locate the high spot.)

JOB SHEET #1

C. Mark high spot with marker

D. Put on protective clothing, welding gloves, and full-face shield

E. Set up, light, and adjust oxyacetylene torch to neutral flame

F. Point flame at marked center of bulge, holding inner white cone of flame about 1/2 inch away from metal

G. Heat an area of metal about the size of a nickel to a dull cherry red or to appropriate color for thickness of metal being worked

(NOTE: The exact size of the heated area and the amount of heat applied depend on the size of the stretched area, the thickness and shape of the metal, and the desired amount of upset wanted.)

CAUTION

Do not touch the metal after heating or a burn could result, despite the fact that you are wearing gloves.

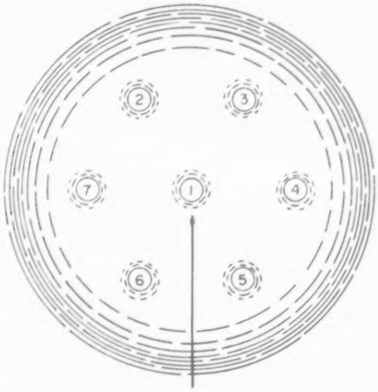
H. Turn off torch and quickly lay it aside

I. Use moderate force to hit center of bulge with a body hammer to drive down high spot

J. Bring dolly quickly up under panel and use hammer and off-dolly technique to straighten the bulged metal; place your hammer blows as shown in Figure 3

(NOTE: Use hammer off-dolly techniques as much as possible. Hammering on-dolly tends to stretch the metal.)

FIGURE 3



First hammer blow is in the center.

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JOB SHEET #1

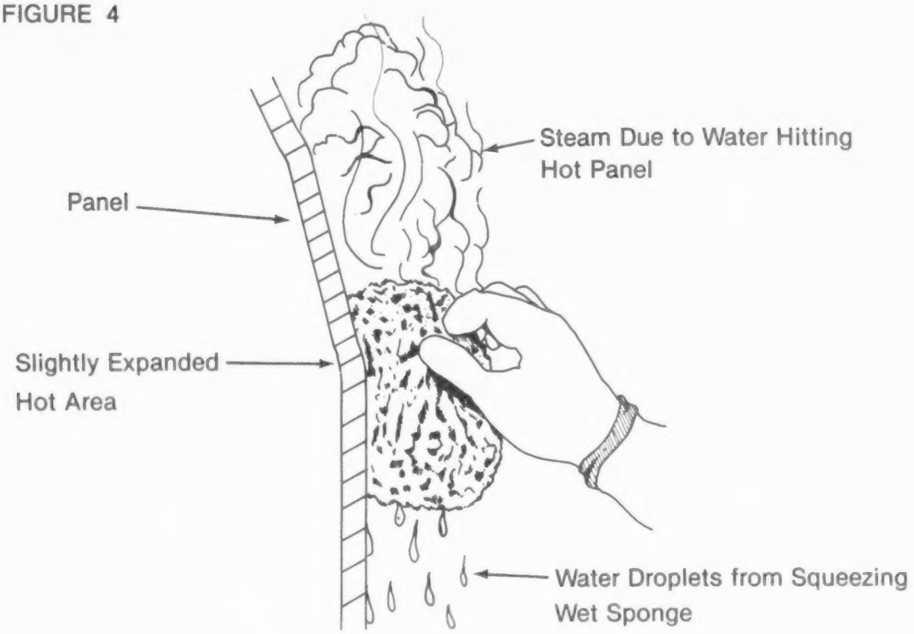
K. After the heated area has turned a bluish-black color and cooled somewhat, quench briefly with a damp sponge (Figure 4)

(NOTE: It is not always desirable to quench a heated panel. The need to quench and the amount of quenching depends on the amount of contraction that needs to take place.)

CAUTION

Take care to prevent steam burns.

FIGURE 4


Steam Due to Water Hitting Hot Panel
Panel
Slightly Expanded Hot Area
Water Droplets from Squeezing Wet Sponge

L. Before heat is completely lost, use hammer and dolly to straighten any warp caused by the quenching operation

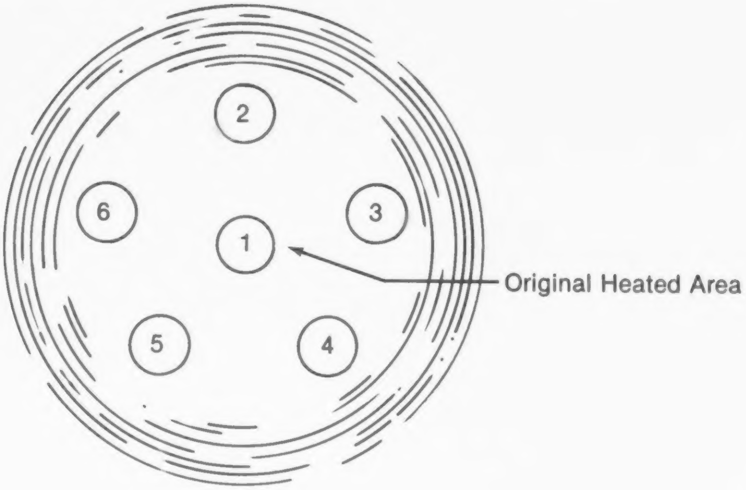
M. Quench metal again with sponge, slowly cooling metal to its normal temperature

N. If possible, check area with straightedge to locate any remaining high spots

O. If another shrink is required, continue heating spots around original heated area as shown in Figure 5

JOB SHEET #1

FIGURE 5



P. Clean work area and return equipment and materials to proper storage

SHRINKING
UNIT IV

JOB SHEET #2 — HEAT SHRINK A GOUGE IN A STEEL PANEL

I. Equipment and materials

A. Shrinking hammer

B. Dolly block of appropriate contour

C. Spoon dolly

D. Pry tools

E. Oxyacetylene torch and #0 welding tip

F. Welding gloves

G. Full-face shield

H. Appropriate protective clothing

I. Fire extinguisher

J. Bucket of water and sponges for quenching

K. Straightedge

L. Eye protection

II. Procedure

A. Check gouge for accessibility from behind and decide on dolly or pry tools best suited for the job

B. Put on protective clothing, welding gloves, and full-face shield

C. Set up, light, and adjust oxyacetylene torch to neutral flame

D. Point flame at deepest point of gouge, holding white inner cone of flame about ½ inch away from metal

E. Heat entire length of gouge to a dull cherry red or to appropriate color for thickness of metal being worked

(NOTE: The exact size of the heated area and the amount of heat applied depend on the size of the damaged area, the thickness and shape of the metal, and the desired amount of upset wanted.)

JOB SHEET #2

CAUTION
Do not touch metal after heating or a burn could result, despite the fact that you are wearing gloves.

F. Turn off torch and quickly lay it aside

G. Drive up area from underneath, using dolly block, spoon dolly, or pry tool, whichever is most appropriate

H. Hold dolly under panel and use shrinking hammer and on-dolly and off-dolly techniques to smooth and straighten the heated metal

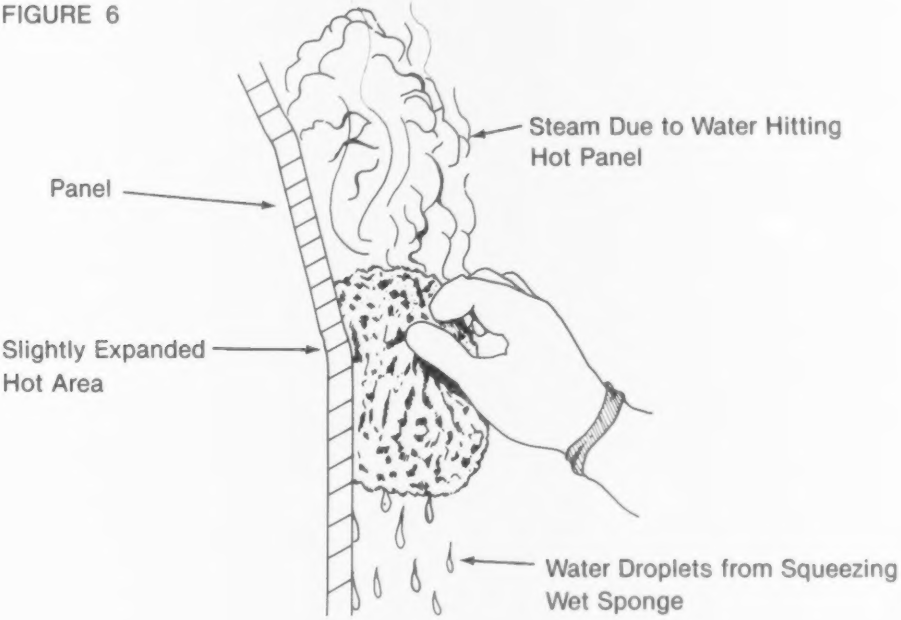
(NOTE: Some on-dolly hammering is acceptable in this operation to help relieve overshrinking.)

I. After heated area has turned a bluish-black color, indicating that it has cooled somewhat, quench briefly with a damp sponge (Figure 6)

(NOTE: It is not always desirable to quench a heated panel. The need to quench and the amount of quenching depends on the amount of contraction desired.)

CAUTION
Take care to prevent steam burns.

FIGURE 6


Steam Due to Water Hitting Hot Panel
Panel
Slightly Expanded Hot Area
Water Droplets from Squeezing Wet Sponge

JOB SHEET #2

J. Before heat is completely lost, use hammer and dolly to straighten any warp caused by quenching operation

K. Quench metal again with sponge, slowly cooling metal to its normal temperature

L. If possible, check area with a straightedge to locate any remaining low spots

M. If low spots remain, repeat operation in those areas until proper level is obtained

N. Clean work area and return equipment and materials to proper storage

SHRINKING
UNIT IV

JOB SHEET #3 — COLD SHRINK A HIGH SPOT IN A SHEET-METAL PANEL

I. Equipment and materials

  A. Pick hammer

  B. Heel dolly

  C. Cotton glove or cloth

  D. Straightedge

  E. Eye protection

II. Procedure

(NOTE: This job sheet outlines the procedure for using the kinking method to "shrink" an accessible, stretched, flat panel. The kinking method may also be used on other shapes of accessible stretched panels. The basic procedure would be the same.)

  A. Put on eye protection

  B. Locate edge of stretched metal by feeling metal with a gloved hand or with a cloth under your hand

  (NOTE: The glove or cloth helps eliminate the friction of your hand on the surface of the metal and makes it easier to locate the edge of the stretched area.)

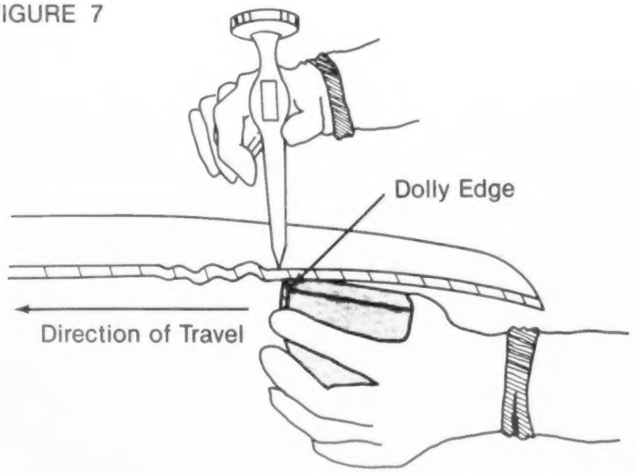
  C. Place flat edge of heel dolly under interior edge of bulge

  (NOTE: Dolly blocks come in a large range of shapes. When kinking a panel that is not flat, choose a dolly that most closely conforms to the contour of the metal being straightened.)

  D. Holding dolly block firmly in one hand, use pick hammer to pick down along edge of dolly, forming a kink along the edge (See Figure 7)

JOB SHEET #3

FIGURE 7

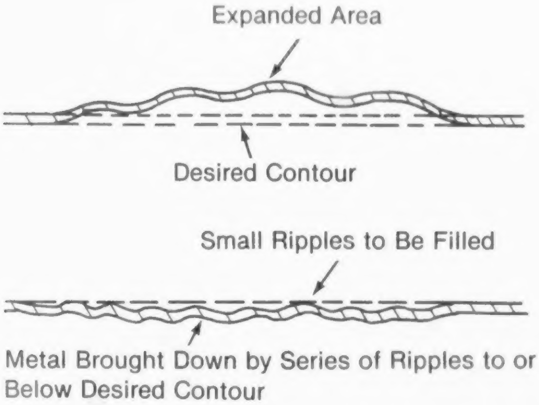


E. Continue this process, moving dolly across length of stretched metal and stopping at short intervals to kink the metal

F. After kinking the length of stretched metal, check level of displaced metal with a straightedge if possible

G. Kink metal until it all checks to approximately 1/8 inch deep, an acceptable level for body filler (Figure 8)

FIGURE 8


Expanded Area
Desired Contour
Small Ripples to Be Filled
Metal Brought Down by Series of Ripples to or Below Desired Contour

Used with permission of The McGraw-Hill Book Company, Gregg Division.

H. Clean work area and return equipment and materials to proper storage

SHRINKING
UNIT IV

JOB SHEET #4 — HEAT SHRINK A HIGH SPOT IN AN ALUMINUM PANEL

I. Equipment and materials

- A. Shrinking hammer
- B. Dolly block of appropriate contour
- C. Oxyacetylene torch and #0 welding tip
- D. Welding gloves
- E. Cotton glove or cloth
- F. Full-face shield
- G. Appropriate protective clothing
- H. Fire extinguisher
- I. Bucket of water and sponges for quenching
- J. Straightedge
- K. Marker
- L. Eye protection

II. Procedure

(NOTE: Heat shrinking aluminum is possible to some degree, but aluminum does not respond to heat shrinking as well as steel does. Extreme care must be taken to avoid further damage to the panel. You may want to practice on a scrap piece of aluminum before attempting the process on a vehicle panel.)

A. Determine highest spot in stretched metal by feeling surface of stretched area with a cotton-gloved hand or with a cloth under the hand

(NOTE: The glove or cloth helps eliminate the friction of your hand on the metal surface and makes it easier to locate the high spot.)

B. Mark high spot with marker

C. Put on protective clothing, welding gloves, and full-face shield

D. Set up, light, and adjust oxyacetylene torch to neutral flame

JOB SHEET #4

E. Point flame at marked center of bulge, holding white inner cone of flame approximately 1 to 1½ inches from surface of metal

F. Heat an area of metal about the size of a nickel until desired expansion is obtained

(NOTE: The exact size of the heated area and the amount of heat applied depend on the size of the stretched area, the thickness and shape of the metal, and the desired amount of upset wanted.)

CAUTION

Heat application to aluminum must be kept below 1200°F to avoid melting the metal. Aluminum does not turn cherry red when heated as does steel; gauging the proper amount of heat comes only from practice and experience.

G. Turn off torch and quickly lay it aside

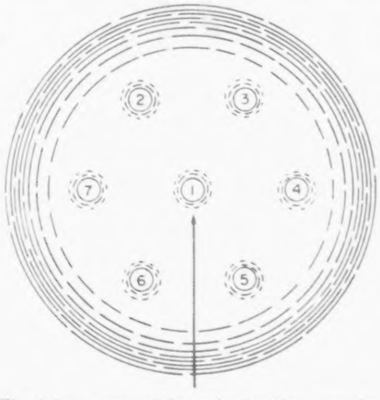
(NOTE: You must work much faster when shrinking aluminum than when shrinking steel because aluminum is such a good conductor that the heat quickly spreads to too large an area and warps adjoining aluminum.)

H. Tap center of heated area very lightly with shrinking hammer to help level high spot

I. Bring dolly quickly up under panel and use hammer and off-dolly technique to smooth and straighten the metal; place your hammer blows as shown in Figure 9

(NOTE: Use hammer off-dolly technique as much as possible. Hammer on-dolly technique tends to stretch the metal.)

FIGURE 9



First hammer blow is in the center.

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JOB SHEET #4

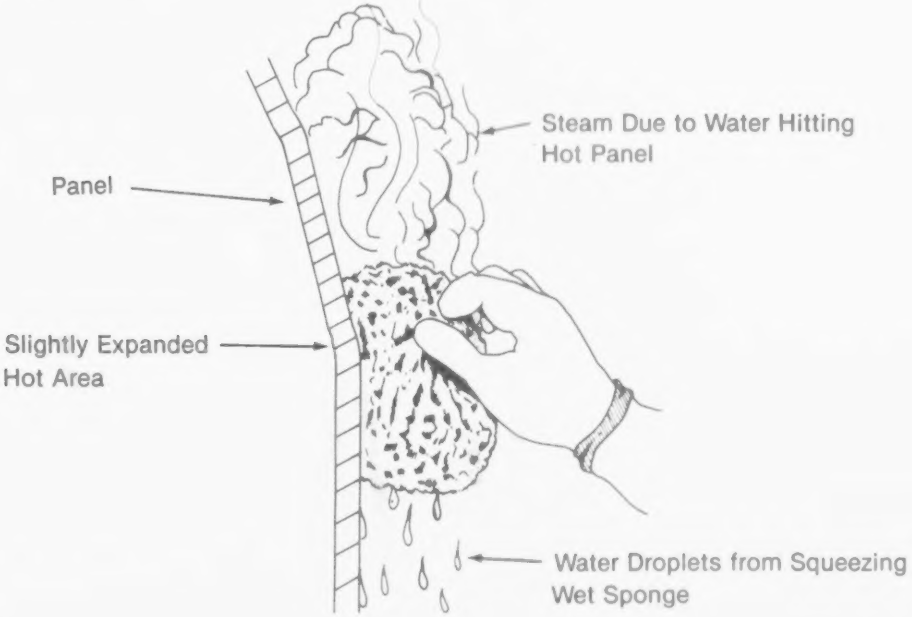
J. After metal has cooled somewhat, quench very briefly with damp sponge (Figure 10)

(NOTE: It is not always desirable to quench a heated panel. The need to quench and the amount of quenching depends on the amount of contraction desired.)

CAUTION

Take care to avoid steam burns, and remember that quenched aluminum shrinks more rapidly than does quenched steel. Such rapid shrinking may result in the formation of buckles that will require further work to repair.

FIGURE 10


Steam Due to Water Hitting Hot Panel
Panel
Slightly Expanded Hot Area
Water Droplets from Squeezing Wet Sponge

K. Before heat is completely lost, quickly use hammer and dolly to straighten any warpage caused by quenching operation

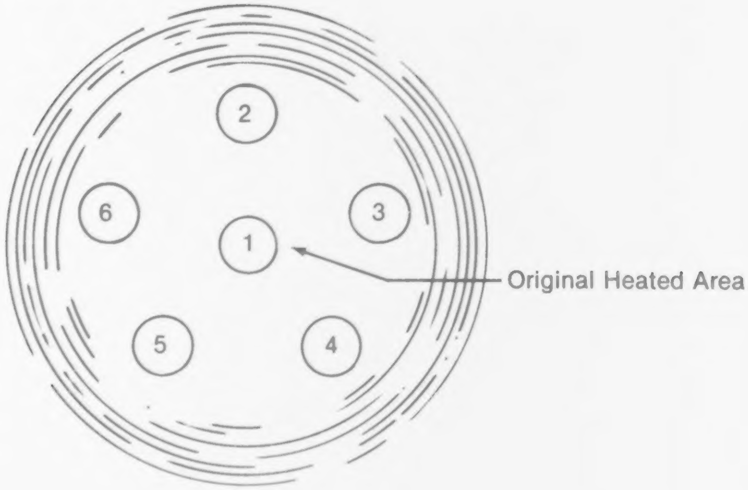
L. Quench metal again with sponge, slowly cooling it to its normal temperature

M. If possible, check area with a straightedge to locate any remaining high spots

N. If another shrink is required, continue heating spots around original heated area as shown in Figure 11

JOB SHEET #4

FIGURE 11



O. Clean work area and return equipment and materials to proper storage

SHRINKING
UNIT IV

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with metal shrinking. Write the correct numbers in the blanks.

_____a. Area in which metal is stretched inward

_____b. Cooling a heated area with water to cause it to shrink

_____c. Process of heating metal to expand and soften it so that desired upset can be made

_____d. Area in which metal is stretched outward

_____e. Swelling and thinning of metal; opposite of upset

_____f. Tool with a waffle face that imprints metal on contact, causing metal to be drawn in or shrunk

_____g. Process of kinking stretched metal without actually shrinking or stretching it

_____h. Shrinking some of the temporarily expanded metal in addition to that which was stretched

_____i. Compression of metal; opposite of stretch

_____j. Area in which an upset has caused an adjoining area to bulge so that it appears to be stretched

1. Heat shrinking
2. Shrinking hammer
3. Gouge
4. High spot
5. False stretch
6. Overshrinking
7. Upset
8. Quenching
9. Cold shrinking
10. Stretch

2. State the principles of heat distortion. Write the correct word or words in the blanks to complete each of the following statements.

a. When heat is applied to metal, the metal ____________

b. As heated metal cools, it ____________ (____________)

c. Quickly cooled heated metal____________ ____________ than slowly cooled heated metal

d. Expansion and contraction of metal are controlled by ____________

____________________________ and ________________________________

TEST

1) The ____________ the area, the more the metal expands and contracts

2) The ____________ the heated area, the greater the expansion and the greater the possibility for warpage or distortion

3. Select from the following list guidelines for heat shrinking sheet metal. Write an "X" in the blank before each correct answer.

_____a. Hit perimeter of heated area with first blow of hammer and then work blows in toward center of heated area

_____b. When hammering heated metal, use dolly with a curved face

_____c. Be prepared to work quickly

_____d. Take care to avoid burns when flattening, shaping, or quenching heated metal

_____e. Generally heat a large area (no smaller than a nickel) at a time

_____f. Have on hand all equipment and materials needed before beginning to heat shrink

_____g. Take care to overheat the metal; heat metal until it is white hot

_____h. Keep inner cone of oxyacetylene flame about 1/4 inch from surface of metal

_____i. Never heat shrink high-strength steel (HSS) or high-strength, low-alloy steel (HSLA) as heat tends to weaken these metals and could result in metal failure

4. List four ways in which heat shrinking aluminum differs from heat shrinking steel.

a. ____

b. ____

c. ____

d. ____

5. Explain reasons for using proper heat when shrinking metal.

a. *If underheated,* ____

____

b. *If overheated,* ____

____

TEST

c. *If properly heated,* ____

____

6. List guidelines for quenching.

   a. *Quench —* ____

   ____

   b. *Do not quench —* ____________________________________

   ____

7. Explain why metal is kinked in the cold shrink process.

   ____

   ____

   ____

(NOTE: Test question 8 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

8. Demonstrate the ability to

   a. Heat shrink a high spot in a steel panel.

   b. Heat shrink a gouge in a steel panel.

   c. Cold shrink a high spot in a sheet-metal panel.

   d. Heat shrink a high spot in an aluminum panel.

SHRINKING
UNIT IV

ANSWERS TO TEST

1. a. 3
   b. 8
   c. 1
   d. 4
   e. 10
   f. 2
   g. 9
   h. 6
   i. 7
   j. 5

2. a. Expands
   b. Contracts (shrinks)
   c. Contracts more
   d. Amount of heat applied, size of area heated
      1) Hotter
      2) Larger

3. c, d, f, i

4. Answer should include any four of the following
   a. Aluminum does not respond to heat shrinking as well as does steel
   b. Work must be performed much faster than with steel
   c. Aluminum does not turn cherry red when heated as does steel
   d. The risk of melting is greater than with steel because aluminum has a lower melting point than steel
   e. Quenching shrinks aluminum more quickly than it does steel
   f. Hot aluminum must be hammered much more lightly than steel to prevent stretching

5. Explanation should include the following
   a. *If underheated,* metal will not soften and upset cannot occur
   b. *If overheated,* metal at hot spot will collapse and form a depression or hole, or the metal will melt, as in the case of aluminum
   c. *If properly heated,* heat will spread over entire area, providing uniform upset and a smooth surface

6. a. *Quench* when a greater amount of upset is required than when heated metal is allowed to cool slowly
   b. *Do not quench* when metal is extremely hot; wait until metal cools somewhat or turns a blue-black color

7. Explanation should include the following
   a. Kinking draws in and "shrinks" metal in damaged area
   b. Kinking brings damaged metal to acceptable level for body filler

8. Performance skills evaluated to the satisfaction of the instructor

BODY FILLING
UNIT V

UNIT OBJECTIVE

After completing this unit, the student should be able to use plastic, fiberglass, and foam body fillers to repair vehicle damage. The student will show this knowledge by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with body filling.
2. Match types of body fillers to their correct descriptions.
3. Complete safety rules for using body fillers.
4. Identify types of plastic body fillers.
5. List auto-body repair jobs for which plastic filler can be used.
6. Select from a list guidelines for mixing plastic body filler and hardener.
7. Discuss advantages and disadvantages of plastic filler.
8. List auto-body repair jobs for which fiberglass filler can be used.
9. Select from a list guidelines for mixing resin and hardener for fiberglass repair.
10. Discuss advantages and disadvantages of fiberglass filler.
11. List uses of foam filler.
12. Select from a list causes of filler failure.
13. Demonstrate the ability to
    a. Use plastic body filler to repair a metal panel.
    b. Use fiberglass body filler to repair a metal panel.
    c. Use foam body filler to repair a rusted-out panel.

BODY FILLING
UNIT V

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Job sheets

      1. Job Sheet #1 — Use Plastic Body Filler to Repair a Metal Panel

      2. Job Sheet #2 — Use Fiberglass Body Filler to Repair a Metal Panel

      3. Job Sheet #3 — Use Foam Body Filler to Repair a Rusted-Out Panel

   E. Test

   F. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials to supplement unit.

      1. Filmstrips

         a. *Plastic Filler Repair*

         b. *Plastic Filler*

         c. *Using Portable Grinders Safely*

         d. *Portable Grinder Attachments and Grinding*

         (NOTE: Filmstrips *a* through *d* are available from Teaching Aids, Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321.)

         e. *Basic Autobody Repair, Unit 3*, available from Career Aids, Incorporated, 20417 Nordhoff Street, Department R, Chatsworth, California 91311; phone 818-341-8200

         (NOTE: This unit contains three color filmstrips, three cassettes, and a teacher's guide. The filmstrips illustrate the characteristics of sheet metals, metal finishing, and plastic filler application and leveling.)

SUGGESTED ACTIVITIES

2. Videocassette (VHS or Beta 1 & 2) — *Fiberglass Rust Repair*, 24 minutes, available from Teaching Aids, Incorporated, P.O. Box 1798, Costa Mesa, California 92628-0798; phone 714-548-9321

3. Equipment and materials for job sheet procedures

4. Samples of plastic, fiberglass, and foam fillers

5. Competency profiles

   (NOTE: Competency profiles are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Explain the general uses of body fillers, stressing that body fillers should be used only on damage that has been roughed out as nearly as possible to the original contour, and only on prepared surfaces.
- Discuss unit and specific objectives.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with body filling.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss types of body fillers.

   SUGGESTIONS:

   - Show students examples of each type of filler.
   - Explain why body solder is becoming obsolete in auto-body repair.

3. Use Information Sheet, Section III to discuss safety rules for using body fillers.

   SUGGESTIONS:

   - Stress the breathing and skin-contact hazards associated with the different fillers.

SUGGESTED ACTIVITIES

- Explain why strict housekeeping is essential in sanding areas.
- Provide each student with a container of hardener, resin, or foam filler. Have the students read the label instructions and cautions and then quiz them orally on their comprehension of the label material.
- Review respirator use and explain why a particle mask is a must when working with fiberglass.
- Relate incidents or case studies concerning the consequences of improper handling or inadequate personal protection when handling body fillers.
- Show students areas of the vehicle that should be protected before applying body filler to specific panels and types of damage.
- Review safety rules associated with metal finishing and the use of grinders and sanders. Show filmstrips *Using Portable Grinders Safely* and *Portable Grinder Attachments and Grinding*.

4. Use Information Sheet, Section IV to discuss the different types of plastic fillers.

   SUGGESTIONS:

   - Show filmstrip *Plastic Filler*.
   - Show students examples of each type of filler listed in this section of the information sheet.
   - Explain the different uses and the advantages and disadvantages of each type of plastic filler.

5. Use Information Sheet, Section V to discuss auto-body repair jobs in which plastic filler can be used.

   SUGGESTIONS:

   - Stress the proper use of plastic filler by explaining areas and types of damage for which body filler should *not* be used.
   - Using a damaged, roughed-out vehicle as an example, point out areas in which plastic filler could and could not be used.
   - Show filmstrip *Plastic Filler Repair*.

SUGGESTED ACTIVITIES

6. Use Information Sheet, Section VI to introduce students to guidelines for mixing plastic body filler and hardener.

   SUGGESTIONS:

   - Demonstrate the differences in curing time by adding increased amounts of hardener to various batches of filler.
   - Demonstrate how set-up time changes under different temperature variations.
   - Demonstrate how to properly mix plastic filler and hardener, and then have students practice mixing the ingredients.
   - Show how improperly cleaned mixing implements introduce crumbs in subsequent mixes.
   - Demonstrate the absorbency of cardboard when used as a mixing sheet.
   - Whip the ingredients and allow to cure to demonstrate how whipping introduces air bubbles that later turn to pinholes or air pockets.
   - Demonstrate and then have students complete procedures outlined in Job Sheet #1.

7. Use Information Sheet, Section VII to discuss advantages and disadvantages of plastic filler.

   SUGGESTION:

   - Demonstrate each of the advantages and disadvantages.

8. Use Information Sheet, Section VIII to discuss auto-body repair jobs in which fiberglass filler can be used.

   SUGGESTIONS:

   - Show videocassette *Fiberglass Rust Repair*.
   - Stress the proper use of fiberglass filler by explaining areas and types of damage for which fiberglass body filler should *not* be used.
   - Explain the difference between fiberglass cloth and fiberglass matting. Show students the various applications for each.
   - Using a damaged, roughed-out vehicle as an example, point out areas in which fiberglass filler could and could not be used.

SUGGESTED ACTIVITIES

9. Use Information Sheet, Section IX to discuss guidelines for mixing resin and hardener for fiberglass repair.

   SUGGESTIONS:

   - Demonstrate the differences in curing time by adding increased amounts of hardener to various batches of resin.
   - Demonstrate how to properly mix fiberglass resin and hardener and then have students practice mixing the ingredients.
   - Show students the results of returning mixed resin-hardener to the resin container.

10. Use Information Sheet, Section X to discuss the advantages and disadvantages of fiberglass filler.

    SUGGESTIONS:

    - Demonstrate each of the advantages and disadvantages listed in this section of the information sheet.
    - Demonstrate and then have students complete procedures outlined in Job Sheet #2.

11. Use Information Sheet, Section XI to discuss foam filler and its uses.

    SUGGESTIONS:

    - Demonstrate how foam filler is mixed in its package.
    - Show students areas on a damaged automobile that could be repaired using foam filler.
    - Demonstrate and then have students complete procedures outlined in Job Sheet #3.

12. Use Information Sheet, Section XII to discuss causes of filler failure.

    SUGGESTIONS:

    - Show students examples of failed body filler and have them analyze the probable cause of failure for each example.
    - Show students what happens when filler is applied to an improperly prepared surface.
    - Show students the results of applying plastic or fiberglass filler too thickly.
    - Show students what happens when the edge of a panel is built up with filler.

SUGGESTED ACTIVITIES

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest if necessary.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Duenk, Lester G., W. Randolph Williams, and Clarence A. Brooks. *Auto Body Repair*. Peoria, Illinois: Chas. A. Bennett Co., Inc., 1977.

B. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

BODY FILLING
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Filler — Material used to level a damaged area

EXAMPLES: Plastic, foam, fiberglass

B. Metal preparation — Step in which all impurities (paint, slag, rust, dirt, protective coatings) are removed from panel surface before body filler is used

C. Hardener — Pigmented cream, liquid, or powder curing agent used in plastic and fiberglass resins

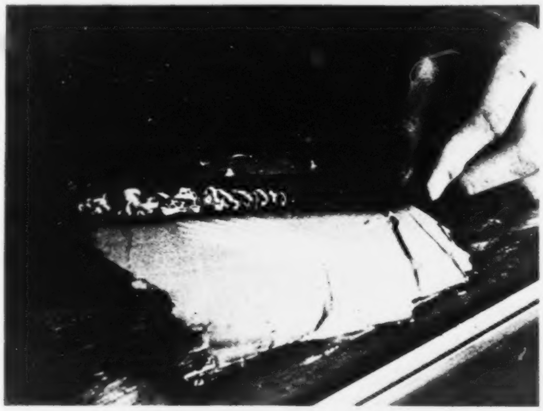
D. Cure — To dry and harden

E. Kneading — Mixing technique used to properly blend two different materials

F. Cheese grater — Coarse, open-toothed file used to shape plastic filler (Figure 1)

EXAMPLE: Surform tool

FIGURE 1



G. Pinholes — Tiny spaces in cured filler caused by improper mixing and too much hardener

H. Air pocket — Air trapped in filler because of improper stirring when mixing

(NOTE: Plastic filler that contains air pockets must be removed and the damaged area must be refilled.)

I. Tin coat — Thin layer of filler skimmed over damaged area

INFORMATION SHEET

II. Types of body fillers

- A. Plastic — Synthetic resin and hardener that can be shaped and molded into any desired form
- B. Fiberglass — Synthetic resin and hardener used with a reinforcing fiber or thread made from glass and woven into a cloth or mat
- C. Foam — Liquid polyurethane material that comes in two parts that, when combined, expand to fill holes and act as a back-up material
- D. Body solder — Soft metal mixture of lead and tin applied to a panel with heat from a torch

  (NOTE: Body solder cannot be used on fiberglass components. While it is a good filler for metal panels, it is expensive and using it as a filler is slow. Body solder is becoming obsolete; fiberglass and plastic are more commonly used in body shops today.)

III. Safety rules for using body fillers

- A. Personal protection
  1. Wear eye protection and protective clothing to guard against sparks created during metal preparation procedure
  2. Use fillers only in well-ventilated areas
  3. Read and obey all label instructions and cautions
  4. Keep filler ingredients away from heat and open flame

     (NOTE: Some ingredients, such as fiberglass resin, are highly explosive.)
  5. Avoid prolonged breathing of vapor
  6. Avoid prolonged or repeated skin contact
     - a. Wear rubber gloves when working with plastic filler

       (NOTE: The ingredients in plastic filler can be absorbed through the skin and cause liver damage.)
     - b. Wear rubber gloves, protective clothing (long sleeves, head cover), and particle mask or respirator when working with fiberglass filler

       (NOTE: The tiny silicone particles in fiberglass filler can embed themselves in the skin and can enter the lungs, causing lung and skin irritation.)

INFORMATION SHEET

7. Wear particle mask or respirator when sanding

    (NOTE: The fine dust created by sanding is very harmful and can cause lung and liver damage. All precautions should be taken to avoid inhaling this dust.)

8. Clean area in which sanding is done with a vacuum cleaner every day

B. Tool and vehicle protection

1. Protect surrounding surfaces from hot sparks during metal preparation procedure

    (NOTE: Sparks can cause permanent damage to glass and can harm painted surfaces.)

2. Protect any moldings, glass, upholstery, or undamaged painted area before applying body filler

3. Before filler sets up, use lacquer thinner to clean all tools and equipment used in the mixing and application of fillers

IV. Types of plastic body fillers

A. Polyester — Mixture of resin and magnesium silicate; resin holds mixture in solution and binds it to surface being repaired; magnesium silicate is added so that product is easy to sand or file

B. Metal — Paste mixture of resin and ground aluminum particles to which hardener is added to make the product cure

(NOTE: Metal plastic filler is sometimes called *metal mender*. While it may cost more than polyester plastic filler, it is often stronger than polyester plastic fillers and thus the cost is offset with high-quality work.)

C. Lightweight — Mixture of plastic and microscopic glass bubbles, which make it light and easy to work; uses a cream hardener for curing

(NOTE: Lightweight plastic filler provides a working time about 15 to 20 minutes longer than polyester plastic filler.)

V. Auto-body repair jobs for which plastic filler can be used

A. Body sections that cannot be fully worked out with tools such as hammers and dollies

(NOTE: Plastic body filler should not be used to fill depressions deeper than about 1/4 inch. Thick fills can crack or break off.)

INFORMATION SHEET

  - B. Sections that cannot be completely restored to original contour by working from inside the panel
  - C. Panel holes or tears (after proper repair)
  - D. Sections weakened or damaged by rust-out (after proper repair)
  - E. Areas that have been patched by welding
  - F. Over seams of replacement panels

- VI. Guidelines for mixing plastic body filler and hardener
  - A. Read and follow all instruction labels on filler and hardener containers
  - B. On your first job, use less rather than more hardener as this will give you more time to work before curing takes place

    (NOTE: On a cold day, the plastic is slower to set up, so you would use more hardener; on a hot day, the plastic sets up faster, so you would use less hardener.)
  - C. Never mix more plastic filler than you can apply in a few minutes

    (NOTE: Properly mixed plastic cures in about 30 minutes. After about 10 minutes, however, it begins to set up and becomes harder to work with and apply.)
  - D. Never return mixed plastic to container as it will contaminate base material and cause it to set up
  - E. Mix ingredients on a clean sheet of safety glass, masonite, or sheet metal

    (NOTE: Avoid using cardboard or other absorbent materials as a base for mixing. Such materials have a tendency to soak up hardener before mixing and application are complete.)
  - F. Mix until base material is uniformly colored throughout

    (NOTE: The base material is white and the hardener is colored to assure thorough mixing.)
  - G. Use a wide-bladed putty knife to knead the two ingredients by scooping from bottom and turning putty knife over to press down on mixture
  - H. Do not whip ingredients: whipping will create air bubbles that may turn to pinholes or air pockets later
  - I. Always thoroughly clean putty knife and mixing sheet in solvent after each use

    (NOTE: Any old material remaining on the sheet or putty knife will introduce crumbs into your next mix and will prevent you from doing a good job.)

INFORMATION SHEET

VII. Advantages and disadvantages of plastic filler

A. Advantages

1. Is quick and easy to apply
2. Adheres well to clean base metal
3. Will not rust or dent
4. Cures fast and forms a hard finish that may be sanded as if it were metal
5. Is low in cost
6. Is long lasting

B. Disadvantages

1. Is likely to crack if applied more than 1/4 inch thick
2. Will not adhere well unless metal surface has been roughened
3. When sanded, creates a fine dust that can cause breathing problems, may collect on other vehicles in the shop, and may sift through paint-booth filters and cause dirty paint

VIII. Auto-body repair jobs for which fiberglass filler can be used

A. Body sections that contain tears, cracks, gouges, or dents

(NOTE: Fiberglass cloth is used in layers for minor repairs. If available, a filler with epoxy resin rather than polyester resin should be used for repairs on metal.)

B. Sections weakened or damaged by rust-out (after repair)

C. Sections or panels that contain holes

(NOTE: Fiberglass mats, which are thicker than fiberglass cloth, are used to repair holes and larger areas of damage.)

IX. Guidelines for mixing resin and hardener for fiberglass repair

A. Read and follow all instruction labels on resin and hardener containers

B. Mix in a clean, unwaxed paper cup with a clean putty knife or spatula

C. Never mix any more resin/hardener than you can use in a few minutes

INFORMATION SHEET

- D. Never return mixed resin/hardener to resin container as it will ruin resin in container
- E. Dispose of unused resin/hardener in a bucket of water

  (NOTE: When mixed, the two materials produce heat, which could cause a fire.)
- F. Thoroughly clean spatula or putty knife after each use

X. Advantages and disadvantages of fiberglass filler

- A. Advantages
  - 1. Is quick and easy to mix and apply
  - 2. Will not rust or dent
  - 3. May be built up to be stronger than steel
  - 4. May be primed, sanded, or painted
  - 5. Is applicable to many auto-body repair jobs
  - 6. Is long lasting
- B. Disadvantages
  - 1. Requires use of rubber gloves and particle mask or respirator
  - 2. Resin is toxic and can cause liver damage
  - 3. Matting or resin may cause skin irritation

    (NOTE: Tiny particles of silicone from the matting can embed themselves in the skin, and resin can be an irritant.)
  - 4. Is difficult to sand because of its gummy, varnishlike properties, so is generally used as a backup for plastic filler

XI. Uses of foam filler

- A. Filling holes and depressed areas, particularly rust-out holes
- B. Deadening sound
- C. Insulating
- D. Eliminating the metal flexing known as *oil canning* or *fluttering*
- E. Stopping wind noises
- F. Reinforcing T-tops and moon roofs
- G. Modifying panels in custom work

INFORMATION SHEET

XII. Causes of filler failure

- A. Failure to prepare surface properly
- B. Applying filler too quickly
- C. Filling over tears in the metal
- D. Filling over rusted spots
- E. Building up edge of panel with filler

  (NOTE: Water will work between the filler and the metal.)

- F. Applying filler over areas that will be heated

  EXAMPLE: Over radiator

  (NOTE: Filler applied over areas that will be heated will crack due to differences in expansion and contraction of metal and filler.)

BODY FILLING
UNIT V

JOB SHEET #1 — USE PLASTIC BODY FILLER TO REPAIR A METAL PANEL

I. Equipment and materials

   A. Appropriate plastic filler

   B. Hardener

   C. Small piece of safety glass, metal, or masonite on which to mix ingredients

   D. Putty knife and plastic spreader

   E. Cheese grater

   F. Mixing spatula

   G. Board file

   H. Sandpaper, #36 grit, #40 grit, and #80 grit

   I. Sanding block

   J. Pneumatic grinder and air compressor

   K. Appropriate grinding discs

   L. Wax and grease remover

   M. Lacquer thinner

   N. Shop towels and cloths

   O. Cotton glove

   P. Straightedge

   Q. Eye protection

   R. Particle mask and respirator

   S. Rubber gloves

   T. Masking tape

   U. Service manual for vehicle being repaired

II. Procedure

   A. Put on eye protection, protective clothing, particle mask, and rubber gloves

B. Prepare surface for filler by removing all impurities with wax and grease remover and grinder

> **CAUTION**
>
> Protect yourself and the vehicle from hot sparks created during metal preparation.

C. Protect with masking tape any moldings, glass, or undamaged painted area adjacent to repair

D. Mix plastic filler

1. Set up equipment and materials in well-ventilated area

2. Read all label instructions and cautions

3. Put on rubber gloves

   > **CAUTION**
   >
   > Avoid prolonged or repeated skin contact. The ingredients in plastic filler can be absorbed through the skin and cause liver damage.

4. Scoop out desired amount of filler with mixing spatula, or dispense from dispenser, and place on a clean mixing board

   (NOTE: Do not mix more filler than you can use in a 10 to 15 minute period.)

5. Add proper amount of hardener, following manufacturer's instructions and taking into account the temperature in the shop

   (NOTE: Remember—the higher the temperature, the quicker the plastic filler will set up and the less hardener you will need to use.)

6. Mix base material and hardener thoroughly until it becomes one color with no streaks; scoop from bottom and turn mixing spatula over to press down on mixture

   (NOTE: Mix carefully. Overmixing results in soft spots that will require doing the job over. Whipping creates air bubbles that will appear later as air pockets or pinholes in the cured filler and will require doing the job over.)

E. Apply filler to damaged area

1. Scoop up small amount of filler on putty knife or plastic spreader

2. Apply a thin coat by skimming filler over surface to be repaired

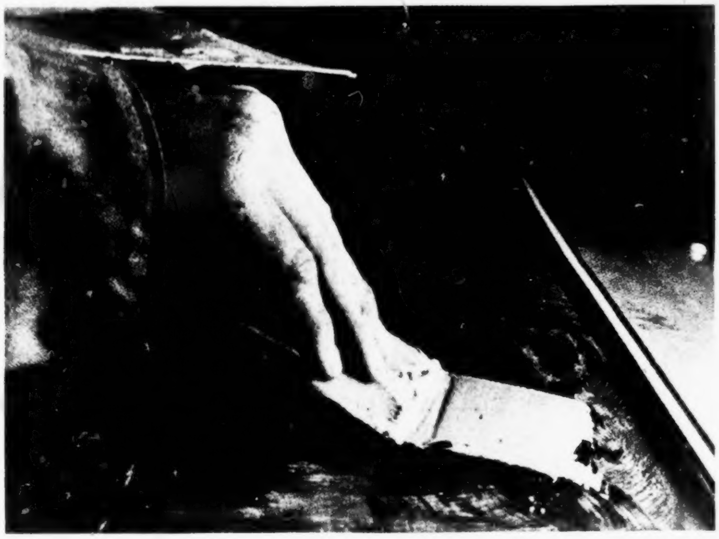
JOB SHEET #1

3. Apply inward pressure to work filler into scratches left by grinding operation

4. Build filler to desired level a thin layer at a time, applying with spreader in even strokes (Figure 2)

   (NOTE: Do not build more than 1/4 inch deep and do not fill all at once. Apply thin layers by holding the spreader correctly: the flatter the spreader, the thicker the layer of filler; the more vertical the spreader, the thinner the layer of filler.)

FIGURE 2



5. While filler is curing, clean mixing board, putty knife or spreader, and mixing spatula with lacquer thinner

> **CAUTION**
>
> Lacquer thinner is highly explosive. Do not expose to heat or flame.

(NOTE: Never return unused filler to the container as this will ruin the base material in the container.)

F. Finish filled area

1. Allow filler to cure completely

2. Test for proper cure by pressing your fingernail into filler to check for hardness; filler should feel like hard cheese

JOB SHEET #1

3. File filled surface with cheese grater, using long, smooth strokes and changing direction of file occasionally to prevent creating waves in one direction

   (NOTE: Some body technicians prefer to grind the filler with a grinding disc or to sand the filler with a 9-inch orbital sander.)

4. If low spots remain in filler, mix and apply another batch of filler and repeat steps 1 through 3 above until smooth surface is obtained

5. Select finish sander to be used, and attach #36-grit or #40-grit sandpaper to face of sander

   (NOTE: Use #36-grit sandpaper on hand file or pneumatic grinder to rough-sand large areas; use #40-grit sandpaper on sanding block for very small areas such as hail dents.)

6. Remove particle mask and put on respirator

7. Connect sander to power source and turn on

8. Place sander flat on surface and sand filler in straight lines, crisscrossing occasionally to prevent waves from appearing in filler

9. Sand until surface is smooth and has proper contour

10. Turn off sander and disconnect from power source

11. Replace sandpaper with #80-grit sandpaper

12. Connect sander to power source and turn on

13. Repeat sanding procedure with #80-grit sandpaper to smooth deep sand scratches left by coarser paper

14. Blend edges smooth with surrounding surface; do not leave high spots

15. Feel sanded surface with cotton-gloved hand or check with straightedge to detect high or low spots

16. Continue sanding with #80-grit sandpaper until all large sand scratches are gone and you are satisfied with the shape, feel, and contour of the surface

17. Turn off sander and disconnect from power source

G. Clean work area and return equipment and materials to proper storage

BODY FILLING
UNIT V

JOB SHEET #2 — USE FIBERGLASS BODY FILLER TO REPAIR A METAL PANEL

I. Equipment and materials

  A. Fiberglass resin and hardener

  B. Fiberglass cloth or mat

  C. Unwaxed paper cup for mixing ingredients

  D. Putty knife

  E. Small paintbrush with nylon bristles

  F. Plastic filler designed for use with fiberglass

  G. Pneumatic grinder and appropriate grinding disc

  H. Air compressor

  I. Orbital sander

  J. #36-grit sandpaper

  K. Particle mask and respirator

  L. Rubber gloves

  M. Eye protection and protective clothing

  N. Scissors or mat knife

  O. Lacquer thinner

  P. Wax and grease remover

  Q. Shop towels and clean cloths

  R. Masking tape

  S. Bucket of water

  T. Service manual for vehicle being repaired

II. Procedure

  A. Put on eye protection, protective clothing, particle mask, and rubber gloves

JOB SHEET #2

B. Prepare surface for filling by removing all impurities with wax and grease remover

C. Scuff-sand surface to ensure good adhesion of filler

> **CAUTION**
>
> Protect yourself and the vehicle from hot sparks created during metal preparation.

D. Protect with masking tape any moldings, glass, or undamaged painted area adjacent to repair

E. Mix fiberglass resin and hardener

1. Set up equipment and materials in well-ventilated area

2. Read all label instructions and cautions

3. Put on rubber gloves

> **CAUTION**
>
> Avoid prolonged or repeated skin contact. Always wear rubber gloves, protective clothing (long sleeves, head cover), and particle mask when working with fiberglass filler. The tiny silicone particles in fiberglass can embed themselves in the skin and can enter the lungs, causing lung and skin irritation.

4. Pour desired amount of resin into unwaxed paper cup

   (NOTE: Do not mix more resin and hardener than you can use in a 10 to 15 minute period.)

> **CAUTION**
>
> Fiberglass resin is highly explosive. Keep away from heat, flame, and sparks.

5. Add proper amount of hardener, following manufacturer's instructions and taking into account the temperature in the shop

   (NOTE: Remember—the higher the temperature, the quicker the resin/hardener will set up and the less hardener will have to be used.)

6. Use putty knife to gently but thoroughly mix hardener and resin

F. Apply resin and cloth or mat to surface

1. Use scissors or mat knife to cut fiberglass cloth or mat into patches about 1 or 2 inches larger than damaged area

JOB SHEET #2

(NOTE: Several layers are usually required. The more layers of fiberglass material used, the stronger the repair.)

2. Dip paintbrush into resin and brush liberally onto prepared surface of vehicle panel
3. Press fiberglass material to brushed surface of panel and then brush resin mixture evenly over entire surface of mat or cloth
4. Pull mat or cloth off panel surface and turn over; brush resin mixture onto this side, making sure that cloth or mat is thoroughly saturated
5. Repeat steps 3 and 4, adding new patches until desired thickness or build-up of material is achieved
6. Dispose of any unused resin/hardener mixture in bucket of water
7. Work out all air pockets with putty knife, working from center toward edges
8. While filler is curing, clean putty knife and any mixing implements with solvent

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

G. Finish fiberglass filler

1. Allow filler to cure completely

   (NOTE: Fiberglass filler usually cures in about 45 minutes, but curing time will vary with the amount of hardener used and the ambient temperature. When cured, fiberglass filler will have a gummy surface.)

2. Trim off any excess matting
3. Remove gummy surface with cleaning solvent
4. Set up body grinder or orbital sander and attach #36-grit abrasive
5. Take off particle mask and put on respirator
6. Turn on grinder and grind repaired area thoroughly until there is a very slight depression in it
7. Apply plastic filler to depressed area as outlined in Job Sheet #1

   (NOTE: Be sure to use plastic filler specifically designed for use on fiberglass.)

8. After filler cures, work it down and finish as described in Job Sheet #1

H. Clean work area and return equipment and materials to proper storage

BODY FILLING
UNIT V

JOB SHEET #3 — USE FOAM BODY FILLER TO REPAIR A RUSTED-OUT PANEL

I. Equipment and materials

A. Package(s) of foam filler

B. Appropriate plastic filler

C. Pneumatic grinder and air compressor

D. #24-grit grinding disc

E. Orbital sander or air file

F. #36-grit sandpaper

G. Sanding block or file board

H. 2-inch-wide masking tape

I. Lacquer thinner

J. Wax and grease remover

K. Scraper

L. Particle mask and respirator

M. Eye protection

N. Rubber gloves

O. Service manual for vehicle being repaired

II. Procedure

A. Put on eye protection, protective clothing, and particle mask

B. Prepare surface for filler by removing all impurities

1. Put on rubber gloves

2. Clean rusted-out area with wax and grease remover, following manufacturer's directions and cautions

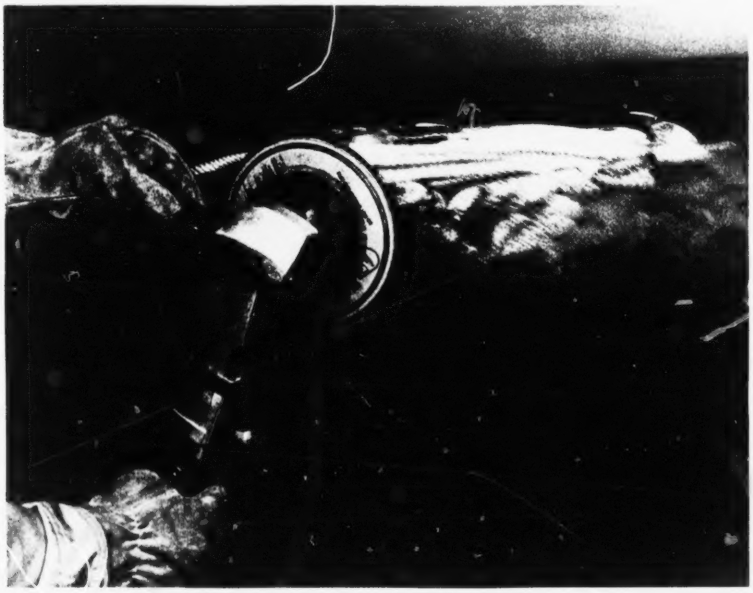
3. Attach #24-grit grinding disc to pneumatic grinder and connect grinder to compressor

JOB SHEET #3

4. Turn on grinder and use crosscut method to grind off all paint and loose rust to 2 to 3 inches beyond rusted-out area (Figure 3)

> **CAUTION**
>
> Protect yourself and the vehicle from hot sparks created during metal preparation.

FIGURE 3



Courtesy of 3M Company.

5. Turn off grinder and set aside
6. Remove any loose rust or undercoating from interior surface by scraping with scraper
7. Apply 2-inch-wide masking tape to outer surface of panel, covering rusted-out area completely (Figure 4)

   (NOTE: The tape will hold the foam in place until it expands and cures.)

JOB SHEET #3

FIGURE 4

Courtesy of 3M Company.

C. Protect with masking tape any moldings, glass, or undamaged painted area adjacent to repair

D. Mix foam filler

   1. Read all label instructions and cautions

   2. Grasp sides of foam filler package with both hands and pull apart to loosen strip of adhesive that separates the two chemicals

   3. Knead package thoroughly, mixing the two chemicals together by working back and forth about twenty-five times

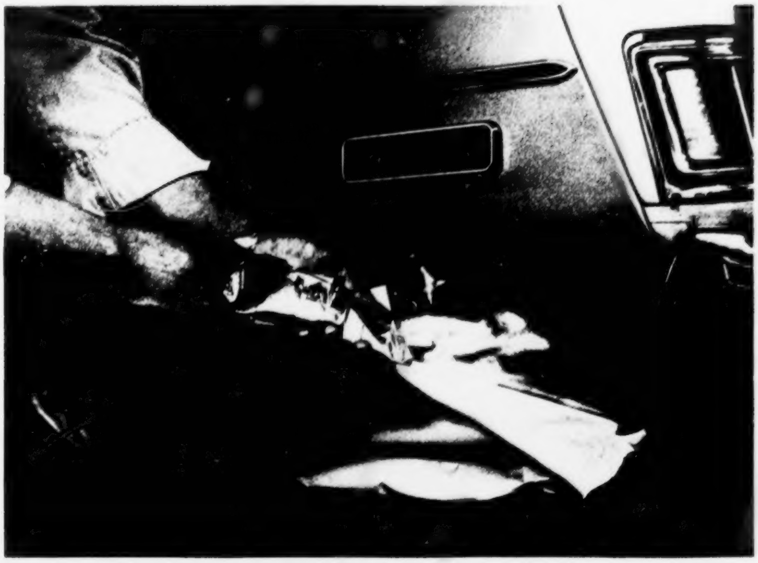
E. Apply foam filler to rusted-out area

   1. Squeeze mixed filler out of package into panel from the inside (Figure 5)

      (NOTE: If panel is inaccessible from the inside, use a knife to make a small hole in the masking tape over a rust hole. Squeeze the foam into the interior through this hole and remask hole.)

JOB SHEET #3

FIGURE 5



Courtesy of 3M Company.

2. Apply enough filler to rusted-out area so that when it expands, it will completely fill area and form a base for plastic filler

F. Finish foam filler

1. Allow filler to cure

   (NOTE: Curing time will vary with the ambient temperature, but foam filler usually cures in 20 to 30 minutes.)

2. Remove masking tape from rusted-out area

3. Set up sander, attach #36-grit sandpaper, and turn on

4. Sand and smooth filler until it is approximately 1/4 inch below metal surface of panel

5. Turn off sander and set aside

6. Clean all sanding dust from surface

7. Apply plastic body filler and finish as outlined in Job Sheet #1

G. Clean work area and return equipment and materials to proper storage

BODY FILLING
UNIT V

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with body filling. Write the correct numbers in the blanks.

_____a. Tiny spaces in cured filler caused by improper mixing and too much hardener

_____b. Thin layer of filler skimmed over damaged area

_____c. Pigmented cream, liquid, or powder curing agent used in plastic and fiberglass resins

_____d. Any material used to level a damaged area

_____e. Air trapped in filler because of improper stirring when mixing

_____f. Coarse, open-toothed file used to shape plastic filler

_____g. To dry and harden

_____h. Mixing technique used to properly blend two different materials

_____i. Step in which all impurities (paint, slag, rust, dirt, protective coatings) are removed from panel surface before body filler is used

1. Hardener
2. Filler
3. Kneading
4. Cure
5. Tin coat
6. Pinholes
7. Metal preparation
8. Air pocket
9. Cheese grater

2. Match types of body fillers to their correct descriptions. Write the correct numbers in the blanks.

_____a. Soft metal mixture of lead and tin applied to a panel with heat from a torch

_____b. Synthetic resin and hardener that can be shaped and molded into any desired form

_____c. Liquid polyurethane material that comes in two parts that, when combined, expand to fill holes and act as a back-up material

_____d. Synthetic resin and hardener used with reinforcing fiber or thread made from glass and woven into a cloth or mat

1. Fiberglass
2. Body solder
3. Plastic
4. Foam

TEST

3. Complete the following safety rules for using body fillers. Write the correct word or words in the blanks.

Personal protection

a. Wear eye protection and protective clothing to guard against ______________ created during metal preparation procedure

b. Use fillers only in ______________ - ______________ areas

c. ______________ and ______________ all label instructions and cautions

d. Keep filler ingredients away from ______________ and ______________ ______________

e. Avoid ______________ ______________ of vapor

f. Avoid prolonged or repeated ______________ contact

  1) Wear ______________ ______________ when working with plastic filler

  2) Wear ______________ ______________ , ______________ ______________ (long sleeves, head cover), and ______________ ______________ or respirator when working with fiberglass filler

g. Wear ______________ ______________ or ______________ when sanding

h. Clean area in which sanding is done with a ______________ ______________ every day

Tool and vehicle protection

a. Protect ______________ ______________ from hot sparks during metal preparation procedure

TEST

b. Protect any _______________ , _______________ , _______________ , or undamaged _______________ area before applying body filler

c. Before filler _______________ _______________ , use _______________ _______________ to clean all tools and equipment used in mixing and application of fillers

4. Identify the following types of plastic fillers. Write the correct names in the blanks.

_________________ a. Paste mixture of resin and ground aluminum particles to which hardener is added to make the product cure

_________________ b. Mixture of plastic and microscopic glass bubbles, which make it light and easy to work; uses a cream hardener for curing

_________________ c. Mixture of resin and magnesium silicate; resin holds mixture in solution and binds it to surface being repaired; magnesium silicate is added so that product is easy to sand or file

5. List four auto-body repair jobs for which plastic filler can be used.

a. ____

b. ____

c. ____

d. ____

6. Select from the following list guidelines for mixing plastic body filler and hardener. Write an "X" in the blank before each correct answer.

_____a. On your first job, use more rather than less hardener as this will give you more time to work before curing takes place

_____b. Read and follow all instruction labels on filler and hardener containers

_____c. Never mix more plastic filler than you can apply in one hour

_____d. Never return mixed plastic to container as it will contaminate base material and cause it to set up

_____e. Mix ingredients on a clean sheet of cardboard

_____f. Mix until base material is uniformly streaked throughout

TEST

______g. Use a wide-bladed putty knife to knead the two ingredients by scooping from bottom and turning putty knife over to press down on mixture

______h. Whip the ingredients to create air bubbles that will strengthen the material later

______i. Always thoroughly clean putty knife and mixing sheet in solvent after each use

7. Discuss advantages and disadvantages of plastic filler.

a. Advantages — ____

____

____

____

____

____

b. Disadvantages — ____

____

____

____

____

8. List auto-body repair jobs for which fiberglass filler can be used.

a. ____

b. ____

c. ____

9. Select from the following list guidelines for mixing resin and hardener for fiberglass repair. Write an "X" in the blank before each correct answer.

______a. Read and follow all instruction labels on resin and hardener containers

______b. Mix on a clean sheet of safety glass with a clean putty knife or spatula

______c. Never mix less resin/hardener than you can use in a few minutes

______d. Never return mixed resin/hardener to resin container as it will ruin resin in container

______e. Thoroughly clean spatula or putty knife after each use

______f. Dispose of unused resin/hardener in a bucket of water

TEST

10. Discuss advantages and disadvantages of fiberglass filler.

    a. Advantages — ______________________________

    ____

    ____

    ____

    ____

    ____

    b. Disadvantages — ______________________________

    ____

    ____

    ____

    ____

    ____

11. List five uses of foam filler.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

12. Select from the following list causes of filler failure. Write an "X" in the blank before each correct answer.

    ______a. Failure to paint surface properly

    ______b. Applying filler too thinly

    ______c. Filling over tears in the metal

    ______d. Filling over rusted spots

    ______e. Building up edge of panel with filler

    ______f. Applying filler over areas that will not be heated

TEST

(NOTE: Test question 13 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

13. Demonstrate the ability to

    a. Use plastic body filler to repair a metal panel.

    b. Use fiberglass body filler to repair a metal panel.

    c. Use foam body filler to repair a rusted-out panel.

BODY FILLING
UNIT V

ANSWERS TO TEST

1. a. 6 d. 2 g. 4
b. 5 e. 8 h. 3
c. 1 f. 9 i. 7

2. a. 2
b. 3
c. 4
d. 1

3. **Personal protection**
   a. Sparks
   b. Well-ventilated
   c. Read, obey
   d. Heat, open flame
   e. Prolonged breathing
   f. Skin
      1) Rubber gloves
      2) Rubber gloves, protective clothing, particle mask
   g. Particle mask, respirator
   h. Vacuum cleaner

   Tool and vehicle protection
   a. Surrounding surfaces
   b. Moldings, glass, upholstery, painted
   c. Sets up, lacquer thinner

4. a. Metal
b. Lightweight
c. Polyester

5. Answer should include any four of the following

   a. Body sections that cannot be fully worked out with tools such as hammers and dollies
   b. Sections that cannot be completely restored to original contour by working from inside the panel
   c. Panel holes or tears (after proper repair)
   d. Sections weakened or damaged by rust-out (after proper repair)
   e. Areas that have been patched by welding
   f. Over seams of replacement panels

ANSWERS TO TEST

6. b, d, g, i

7. Discussion should include the following

    a. Advantages
        1) Is quick and easy to apply
        2) Adheres well to clean base metal
        3) Will not rust or dent
        4) Cures fast and forms a hard finish that may be sanded as if it were metal
        5) Is low in cost
        6) Is long lasting

    b. Disadvantages
        1) Is likely to crack if applied more than ¼ inch thick
        2) Will not adhere well unless metal surface has been roughened
        3) When sanded, creates a fine dust that can cause breathing problems, may collect on other vehicles in the shop, and may sift through paint-booth filters and cause dirty paint

8. a. Body sections that contain tears, cracks, gouges, or dents
    b. Sections weakened or damaged by rust-out (after repair)
    c. Sections or panels that contain holes

9. a, d, e, f

10. Discussion should include the following

    a. Advantages
        1) Is quick and easy to mix and apply
        2) Will not rust or dent
        3) May be built up to be stronger than steel
        4) May be primed, sanded, or painted
        5) Is applicable to many auto-body repair jobs
        6) Is long lasting

    b. Disadvantages
        1) Requires use of rubber gloves and particle mask or respirator
        2) Resin is toxic and can cause liver damage
        3) Matting or resin may cause skin irritation
        4) Is difficult to sand because of its gummy, varnishlike properties, so is generally used as a backup for plastic filler

ANSWERS TO TEST

11. Answer should include any five of the following

    a. Filling holes and depressed areas, particularly rust-out holes
    b. Deadening sound
    c. Insulating
    d. Eliminating the metal flexing known as *oil canning* or *fluttering*
    e. Stopping wind noises
    f. Reinforcing T-tops and moon roofs
    g. Modifying panels in custom work

12. c, d, e

13. Performance skills evaluated to the satisfaction of the instructor

FIBERGLASS REPAIR
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to repair damage to fiberglass auto-body panels and parts, following prescribed safety rules. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with fiberglass repair.
2. List advantages of fiberglass auto-body construction.
3. State ways in which fiberglass repairs differ from metal or plastic repairs.
4. Select from a list guidelines for proper repair of fiberglass panels and parts.
5. Complete safety precautions to observe when working with fiberglass.
6. Demonstrate the ability to
    a. Repair minor surface damage to a fiberglass panel.
    b. Repair a crack in a fiberglass panel.
    c. Repair a puncture in a fiberglass panel.
    d. Repair a shattered fiberglass panel.
    e. Replace a missing curved section of fiberglass panel.

FIBERGLASS REPAIR
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

  A. Objective sheet

  B. Suggested activities

  C. Information sheet

  D. Job sheets

    1. Job Sheet #1 — Repair Minor Surface Damage to a Fiberglass Panel

    2. Job Sheet #2 — Repair a Crack in a Fiberglass Panel

    3. Job Sheet #3 — Repair a Puncture in a Fiberglass Panel

    4. Job Sheet #4 — Repair a Shattered Fiberglass Panel

    5. Job Sheet #5 — Replace a Missing Curved Section of Fiberglass Panel

  E. Test

  F. Answers to test

II. Instructor's guide

  A. Review unit and plan presentation.

  B. Order or obtain materials to supplement unit.

    1. Filmstrips

      (NOTE: The two filmstrips listed below are part of a series of five filmstrips, five cassettes, and program guide available from Prentice-Hall Media, ServCode DU, 150 White Plains Road, Tarrytown, New York 10591. Order the series *Autobody Fiberglass and Plastic Repairs*, DU1274.)

      a. "Repairing a Cracked Fiberglass Fender"

      b. "Replacing a Fiberglass Panel"

    2. Fiberglass panels for demonstration purposes

    3. Equipment and materials for job sheet procedures

SUGGESTED ACTIVITIES

4. Competency profiles

   (NOTE: Competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss unit and specific objectives.
- Explain that a number of modern automobile bodies are made with fiberglass rather than sheet metal and that a fiberglass body is repaired by quite different techniques than those used to repair metal bodies.
- Explain that many fiberglass panels and parts can be repaired more economically than they can be replaced. Therefore, fiberglass repairs can be expected to be a growing part of the workload in every body shop.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with fiberglass repair.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss advantages of fiberglass auto-body construction.

   SUGGESTION:

   - Point out or demonstrate each of the advantages on a vehicle with a fiberglass body.

3. Use Information Sheet, Section III to discuss the ways in which fiberglass repairs differ from metal or plastic repairs.

4. Use Information Sheet, Section IV to discuss guidelines for proper repair of fiberglass panels and parts.

   SUGGESTION:

   - Explain the importance of each of the guidelines.

SUGGESTED ACTIVITIES

EXAMPLES: Explain *why* the repair surface must be thoroughly cleaned; *why* rough edges and pieces are removed; *why* the repair is made from the inside to the outside when possible.

5. Use Information Sheet, Section V to stress safety precautions that the auto-body technician should observe when working with fiberglass.

   SUGGESTIONS:

   - Mix resin and hardener to demonstrate how the mixture produces heat.
   - Stress the need to cover the head and all exposed skin to protect against irritating fiberglass particles released during grinding and sanding.
   - Provide students with samples of various fiberglass repair products. Have students read the instructions and cautions on the product labels. Stress the need to read the labels *before* using the products.
   - Demonstrate how to use lacquer thinner to clean hands and tools. Stress the explosive properties of this solvent.
   - Ask for a student volunteer to model the protective clothing necessary for working with fiberglass. Have the volunteer demonstrate how to put on a respirator or particle mask and how to close cuffs with rubber bands. Show students how to apply protective skin cream if it is used in your shop.

6. Demonstrate and discuss procedures outlined in Job Sheets #1 through #5.

7. Have students complete Job Sheets #1 through #5.

F. Give test.

G. Critique test and discuss in class.

H. Complete appropriate section of competency profiles.

III. Unit references

A. Duenk, Dr. Lester G., Dr. W. Randolph Williams, and Clarence S. Brooks. *Auto Body Repair*. Peoria, Illinois: Chas. A. Bennett Co., Inc., 1977.

B. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*. Indianapolis, Indiana: The Bobbs-Merrill Company, Inc., 1983.

C. Tait, Alex, A. G. Deroche, and N. N. Hildebrand. *The Principles of Autobody Repairing and Repainting*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971.

FIBERGLASS REPAIR
UNIT I

INFORMATION SHEET

I. Terms and definitions

- A. Fiberglass — Molten glass that has been drawn out into tiny threadlike fibers
- B. Fiberglass cloth — Loosely woven, thin strands of fiberglass used to repair minor damage
- C. Fiberglass mat — Tightly woven, thick strands of fiberglass used to repair major damage
- D. Mold-making veil — Very fine fiberglass cloth used to shape repair part
- E. Fiberglass filler — Powdered fiberglass and polyester resin
- F. Polyester resin — Agent that bonds only with fiberglass
- G. Epoxy resin — Agent that bonds well with both fiberglass and metal
- H. Hardener — Catalyst that speeds curing time of resin mixture
- I. Saturate — To soak fiberglass cloth or mat with resin/hardener mixture
- J. Shingled — Overlapped as roofing materials on a house
- K. Stop drilling — Process of drilling a small hole at each end of a crack to prevent crack from spreading

  (NOTE: When a repair cannot be made immediately, stop drilling is performed to prevent the crack from getting larger before the repair can be made.)
- L. Flash time — Time required for thinner to evaporate from surface
- M. Curing — Drying and hardening of fiberglass resin
- N. Bevel — To grind to an angle

II. Advantages of fiberglass auto-body construction

- A. Possesses extraordinary strength
- B. Is very durable
- C. Is highly resistant to fire
- D. Will not rust or corrode

INFORMATION SHEET

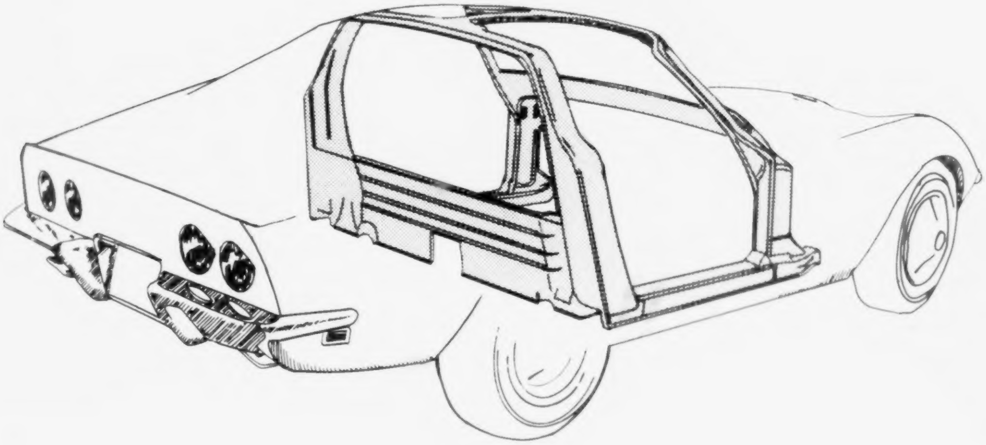
E. Is completely waterproof

F. Is lightweight and never rattles

G. Damage tends to be localized close to point of impact rather than spread over a wide area of panel as with sheet-metal collision damage

(NOTE: Because fiberglass bodies do not bend under pressure as metal bodies do, fiberglass usually cracks, chips, or shatters under impact. Fiberglass bodies must be very well reinforced when they are built and when they are repaired. Many fiberglass bodies are reinforced with steel members to protect the occupants in the event of roll-over. See Figure 1 below.)

FIGURE 1



III. Ways in which fiberglass repairs differ from metal or plastic repairs

A. Fiberglass does not stretch or give and thus cannot be worked with tools as can metal

B. Fiberglass cannot be welded, molded, or shaped with heat as can plastic or metal

C. Because fiberglass cannot be worked or shaped, damaged material must be removed and area reinforced, patched, or replaced

D. Raised fiberglass areas cannot be tapped down as can raised metal areas, so fiberglass repairs are applied from *inside* to *outside* when possible

INFORMATION SHEET

IV. Guidelines for proper repair of fiberglass panels and parts

   A. Analyze extent and type of damage to determine most suitable repair procedure

   B. Mask area around damage to avoid damage to paint

   C. Thoroughly clean inner and outer surfaces of panel

   D. Remove rough edges and all loose or broken material

   E. Rough sand and bevel edges to ensure good adhesion

   F. Reconstruct damaged area from inside out when possible

   G. Thoroughly saturate cloth or mat with resin/hardener and work out all air bubbles

   H. Build the repair, applying cloth or mat in layers

   I. Allow time for resin/hardener to cure before preparing area for paint

V. Safety precautions to observe when working with fiberglass

   A. Always wear rubber gloves when handling resin or fiberglass

   (NOTE: A special protective skin cream may also be applied.)

   B. Wear a respirator, hood, and safety glasses; button up collar and shirt sleeves; and secure shirt sleeves with rubber bands around the cuffs when grinding or sanding fiberglass

   (NOTE: When worked with a grinder or sander, fiberglass breaks up into millions of small particles of glass. If inhaled, these particles can cause respiratory illness. Particles that settle on unprotected parts of the body can cause serious skin irritation.)

   C. Carry out all repair procedures in a well-ventilated area so that exhaust system can draw out toxic resin fumes

   D. Keep an appropriate fire extinguisher nearby at all times

   E. Mix only amount of resin and hardener needed, and dispose of any unused resin/hardener by dropping it into a bucket of water

   (NOTE: The chemical reaction between resin and hardener produces heat. Left unattended, the heat buildup can cause a fire.)

   F. Read *all* instruction and caution labels on fiberglass repair products before using product

INFORMATION SHEET

G. Remove any resin deposits on hands or tools with lacquer thinner before resin jells or hardens

(NOTE: Wash hands with soap and water after cleaning with lacquer thinner.)

H. Use lacquer thinners—highly flammable substances—with the greatest care and caution

FIBERGLASS REPAIR
UNIT I

JOB SHEET #1 — REPAIR MINOR SURFACE DAMAGE TO A FIBERGLASS PANEL

I. Equipment and materials

  A. Wax and grease remover

  B. Body grinder or orbital sander

  C. Air gun

  D. Rubber hand-sanding block

  E. 400-grit wet sandpaper

  F. 36-grit abrasive disc

  G. 40-grit and 60- or 80-grit production paper

  H. Tack cloth

  I. Clean cloths

  J. Primer-surfacer

  K. Lacquer thinner containing no additives

  L. ¼-inch drill and cone-shaped sanding attachment

  M. Fiberglass filler, resin, and hardener (epoxy resin may be used if desired)

  N. Putty knife or squeegee

  O. Bucket of water

  P. Masking tape

  Q. Protective clothing

    1. Rubber gloves or protective skin cream

    2. Eye protection

    3. Respirator and particle mask

    4. Head cover or hood

JOB SHEET #1

II. Procedure for repairing minor scratches in the paint

(NOTE: Minor scratches in the glaze coat, small dents, pits, and surface cracks merely require a filler buildup to repair.)

A. Set up equipment and materials in a well-ventilated area

B. Put on protective clothing

C. Clean damaged area

1. Mask area around damage to protect undamaged finish

2. Clean damaged area with wax and grease remover, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling fumes from the wax and grease remover.

D. Wet-sand area with 400-grit sandpaper, taking care to avoid removing the fiberglass under the paint

(NOTE: If the surface is flat, a rubber sanding block is helpful.)

E. Wipe area clean with a dry cloth

F. Wipe again with a clean tack cloth to remove all sanding dust

CAUTION

Do not use liquid cleaner on bare fiberglass. Penetration of cleaning solvents into fiberglass can cause paint adherence problems later.

G. Apply primer surfacer, following manufacturer's instructions and allowing flash time between coats

H. Wet-sand, using 400-grit sandpaper

I. Blow off surface with air gun to remove all sanding dust

J. Clean surface with lacquer thinner containing no additives; follow manufacturer's application instructions

(NOTE: The surface is now ready for painting. Fiberglass is painted in the same manner as sheet metal.)

K. Clean work area, remove protective clothing, and return equipment and materials to proper storage

JOB SHEET #1

III. Procedure for small dents, pits, and surface cracks

A. Set up equipment and materials in a well-ventilated area

B. Put on protective clothing

C. Clean damaged area

1. Mask area around damage to protect undamaged finish

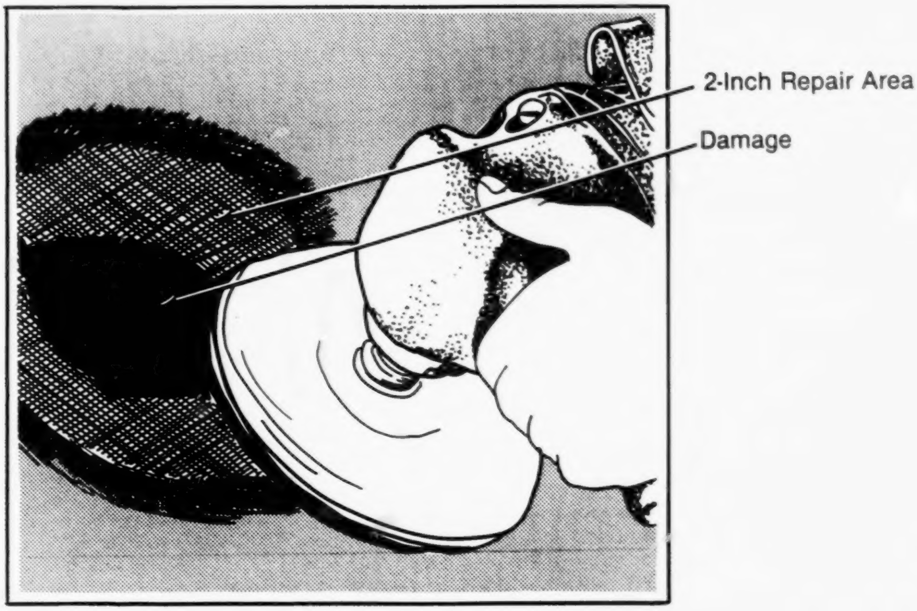
2. Clean damaged area with wax and grease remover, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling fumes from the wax and grease remover.

D. Grind repair area with 36-grit disc—or sand with 60- or 80-grit production paper—to remove paint at least 2 inches from damage on all sides (Figure 2)

FIGURE 2



E. Use 1/4-inch drill with cone or disc to remove any paint from pits or crevices that could not be reached

(NOTE: Rough sanding is necessary to ensure good adhesion of the fiberglass filler.)

JOB SHEET #1

F. Remove all grinding dust with a clean tack cloth

G. Mix fiberglass filler, resin, and hardener, following manufacturer's instructions and cautions

> **CAUTION**
>
> Wear rubber gloves or apply protective skin cream. Avoid inhaling the toxic resin fumes.

H. Apply mixed filler to damaged area with putty knife or squeegee, making certain that filler is worked into depressions to ensure good adhesion

I. Build area to correct contour a layer at a time

J. Dispose of any unused resin/hardener material in bucket of water

K. Allow filler to cure for time specified by manufacturer

(NOTE: Remember, the higher the temperature, the quicker the filler will cure.)

L. Grind cured filler to proper contour with 36-grit disc, or hand-sand with 40-grit production paper

M. Finish sand, clean, and prime for painting as described in steps D through J of procedure for repairing surface scratches

N. Clean work area, remove protective clothing, and return equipment and materials to proper storage

FIBERGLASS REPAIR
UNIT I

JOB SHEET #2 — REPAIR A CRACK IN A FIBERGLASS PANEL

I. Equipment and materials

A. Wax and grease remover

B. Masking tape

C. Body grinder or orbital sander

D. 36-grit abrasive disc and 60- or 80-grit production paper

E. Tack cloth

F. Clean cloths

G. Electric drill and drill bits

H. Scrap metal for reinforcing strips if necessary

I. #6 or #8 sheet-metal screws

J. Screwdriver

K. C-clamps

L. Hacksaw

M. Heat gun or lamp

N. Fiberglass filler, resin, and hardener (epoxy resin may be used if desired)

O. Square baking pan and paintbrush with nylon bristles

P. Plastic filler designed for use on fiberglass

Q. Small square of masonite, glass, or metal on which to mix plastic filler

R. Putty knife or squeegee

S. Fiberglass matting and cloth

T. Scissors

U. Unwaxed paper cup and mixing spatula

V. Bucket of water

JOB SHEET #2

W. Lacquer thinner

X. Air gun

Y. Protective clothing

   1. Rubber gloves or protective skin cream

   2. Eye protection

   3. Respirator and particle mask

   4. Headcover or hood

II. Procedure for crack accessible from the back

(NOTE: Cracked panels are those in which the damage extends all the way through the fiberglass panel. Even small cracks should be repaired because they tend to get larger as they are subjected to stress in everyday use of the vehicle. If repairs cannot be made right away, stop drill the crack to prevent it from spreading.)

A. Set up equipment and materials in a well-ventilated area

B. Put on protective clothing

C. Clean area around crack

   1. Mask area around damage to protect undamaged finish

   2. Clean both back and front of damaged area with wax and grease remover, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling fumes from wax and grease remover.

D. Grind repair area on *back* of panel with 36-grit disc—or sand with 60- or 80-grit production paper—to roughen surface 8 to 10 inches around crack

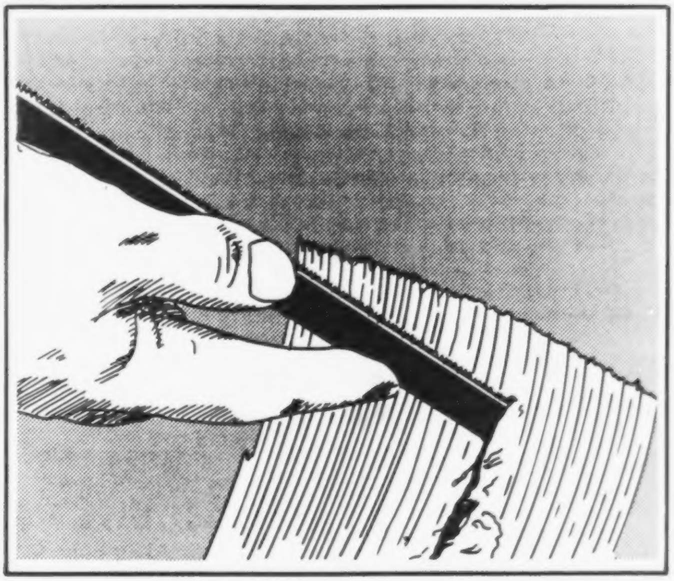
E. Grind repair area on *front* of panel with 36-grit disc—or sand with 60- or 80-grit production paper—to remove paint at least 3 inches from damage on all sides

(NOTE: Take care to avoid removing the fiberglass under the paint.)

F. Use hacksaw blade to remove rough edges of crack, making a gap 1/8 inch wide or slightly wider (See Figure 3)

JOB SHEET #2

FIGURE 3



G. Bevel edges of crack on front of panel to ensure good adhesion

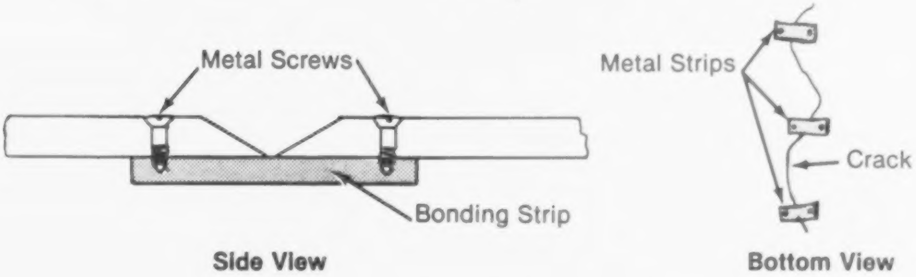
H. Carefully align edges of crack and hold in alignment with C-clamps

I. If C-clamps cannot be used, follow procedure below

1. Cut several strips of scrap metal 2 to 3 inches long and 1 inch wide
2. Drill a 1/8-inch hole in each end of metal strips
3. Fasten metal strips across back of crack, using #6 or #8 sheet-metal screws (Figure 4)

   (NOTE: It is very important that the edges of the crack are in perfect alignment.)

FIGURE 4



JOB SHEET #2

J. Cut pieces of fiberglass matting large enough to cover crack and extend beyond it 2 to 3 inches in all directions

K. Cut small strips to cover areas where C-clamps or metal strips are located

(NOTE: These fiberglass strips will be used to reinforce the area under the C-clamps or metal strips after clamps or strips are removed.)

L. Clean back of area with tack cloth to remove all dust and dirt particles

M. Mix resin and hardener in unwaxed paper cup, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

N. Saturate large strips of fiberglass matting with resin/hardener mixture, either by brushing (Figure 5) or by immersing (Figure 6)

FIGURE 5

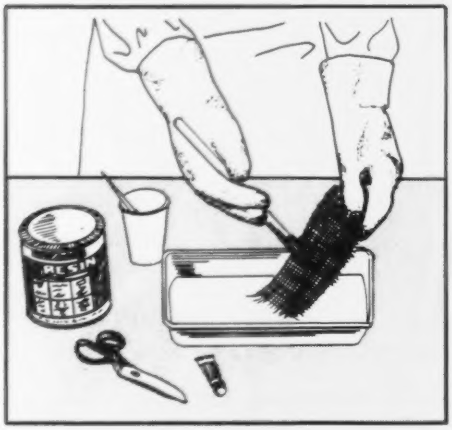
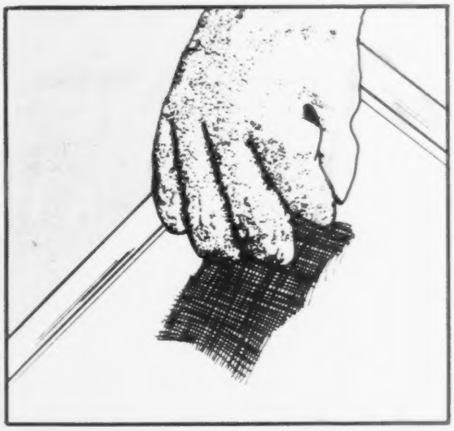


FIGURE 6



JOB SHEET #2

O. Roll pieces of matting—one at a time—over underside of crack to reinforce it

(NOTE: Do not place matting over clamps or metal strips.)

P. Work out any air bubbles with putty knife, working from center toward edges

Q. Dispose of any unused resin/hardener mixture in bucket of water

R. Allow reinforcement strips to cure for period of time specified by manufacturer

(NOTE: Use heat gun or lamp to speed curing time if desired.)

S. Remove C-clamps or metal strips

T. Mix another batch of resin/hardener, and saturate small fiberglass strips, either by brushing or immersing (See Figures 4 and 5)

U. Apply small fiberglass strips to areas where clamps or metal strips were located

V. Fill beveled side of crack with resin mixture

W. Dispose of any unused resin/hardener mixture in bucket of water

X. While resin/hardener is curing, clean putty knife and any mixing implements with lacquer thinner

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

Y. Grind cured resin/hardener to scuff surface

Z. Mix and apply plastic filler to crack on front of panel; allow to cure for period of time recommended by manufacturer

(NOTE: Be sure to use plastic filler specifically designed for use on fiberglass. Instructions for mixing and applying plastic filler over fiberglass can be found in Section B, Unit V, "Body Filling," Job Sheet #2.)

AA. Finish sand, clean, and prime for painting as described in steps D through J in Job Sheet #1 procedure for repairing surface scratches

III. Procedure for crack that is inaccessible from the back

A. Set up equipment and materials, put on protective clothing, and clean outside of panel around crack as outlined in procedure for crack accessible from back

B. Working from outside of panel, use hacksaw blade to cut away rough or jagged edges

JOB SHEET #2

C. Grind area with 36-grit disc—or sand with 60- or 80-grit production paper—to roughen surface and remove paint at least 3 inches in all directions

(NOTE: Take care to avoid removing the fiberglass under the paint.)

D. Bevel edges of crack to a wide "V" taper from outside to inside

E. Scuff-sand beveled edges

F. Clean area thoroughly with tack cloth to remove grinding and sanding dust

G. Cut enough fiberglass matting and cloth strips to build up contour of damaged area slightly past desired contour; cut matting strips to overlap repair area about 2 inches

H. Mix resin and hardener in unwaxed paper cup, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

I. Saturate fiberglass with resin/hardener mixture, either by brushing or immersing (See Figures 5 and 6)

J. Apply matting strips and then cloth strips one at a time on outside of damaged area

K. Work out any air bubbles with putty knife, working from center to edges

L. Repeat steps J and K until desired contour is reached

M. Dispose of any unused resin/hardener mixture in bucket of water

N. Use heat lamp or heat gun to speed curing time

O. While matting and resin/hardener material cures, clean putty knife and any mixing implements with lacquer thinner

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

P. Grind to proper contour with 36-grit disc or 40-grit production paper

Q. Use air gun to clean surface of grinding dust particles

JOB SHEET #2

R. Mix and apply plastic filler to repair area on front of panel

(NOTE: Be sure to use plastic filler specifically designed for use on fiberglass. Instructions for mixing and applying plastic filler over fiberglass can be found in Section B, Unit V, "Body Filling," Job Sheet #2.)

S. Allow to cure for period of time recommended by manufacturer, and then grind to proper contour with 36-grit disc or 40-grit production paper

T. Finish sand, clean, and prime for painting as described in steps D through J in Job Sheet #1 procedure for repairing surface scratches

U. Clean work area, remove protective clothing, and return equipment and materials to proper storage

FIBERGLASS REPAIR
UNIT I

JOB SHEET #3 — REPAIR A PUNCTURE IN A FIBERGLASS PANEL

I. Equipment and materials

A. Wax and grease remover

B. Masking tape

C. Body grinder or orbital sander

D. 36-grit abrasive disc

E. 40-grit and 60- or 80-grit production paper

F. Tack cloth

G. Clean cloths

H. Hacksaw

I. Heat gun or lamp if desired to speed curing time

J. Fiberglass matting and cloth, resin and hardener (epoxy resin may be used if desired)

K. Plastic bags such as those used by dry cleaners

L. Plastic filler designed for use on fiberglass

M. Small square of masonite, glass, or metal on which to mix plastic filler

N. Putty knife or squeegee

O. Scissors

P. Unwaxed paper cup and mixing spatula

Q. Bucket of water

R. Lacquer thinner

S. Air gun

T. Protective clothing

1. Rubber gloves or protective skin cream

2. Eye protection

JOB SHEET #3

3. Respirator and particle mask

4. Headcover or hood

II. Procedure

A. Set up equipment and materials in a well-ventilated area

B. Put on protective clothing

C. Clean damaged area

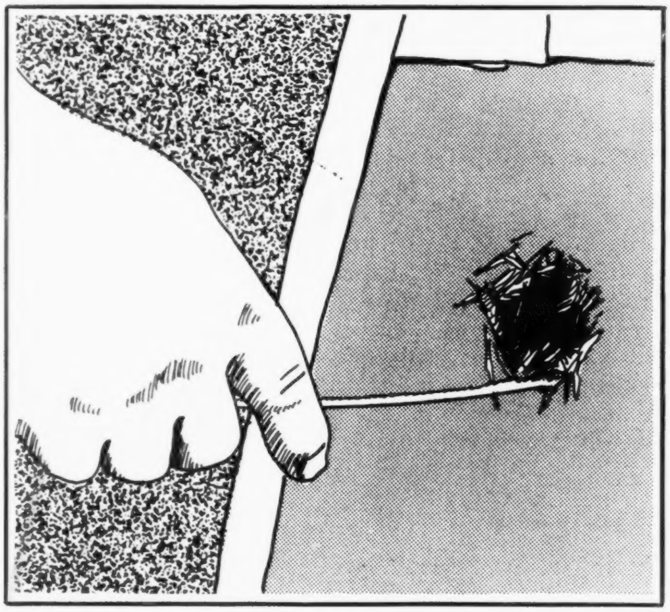
1. Mask area around damage to protect undamaged finish

2. Clean both back and front of damaged area with wax and grease remover, following manufacturer's instructions and cautions

> **CAUTION**
>
> Wear rubber gloves or apply protective skin cream. Avoid inhaling fumes from wax and grease remover.

D. Use hacksaw blade to remove any loose fiberglass from damaged area; if damage is small, enlarge area (Figure 7)

FIGURE 7



JOB SHEET #3

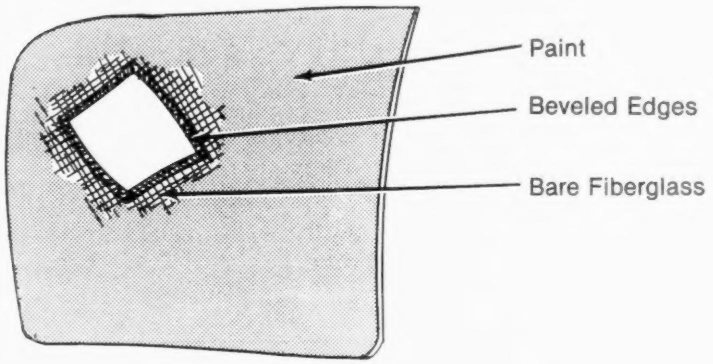
E. Grind repair area on back of panel with 36-grit disc—or sand with 60- or 80-grit production paper—to roughen surface 3 to 4 inches from damage on all sides

F. Grind repair area on front of panel with 36-grit disc—or sand with 60- or 80-grit production paper—to remove paint and expose base fiberglass 2 to 3 inches from damage in all directions

(NOTE: Take care to avoid removing the fiberglass under the paint.)

G. Bevel edges of hole to about 45 degrees as shown in Figure 8

FIGURE 8



H. Cut two pieces of fiberglass matting, one about 2 inches larger than hole on all sides, the other to just barely fit within damaged area

(NOTE: The large piece will be used on the inside of the panel and the smaller piece will be placed over it on the outside of the panel so that the repaired area is level with the rest of the panel.)

I. Mix resin and hardener in an unwaxed paper cup, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

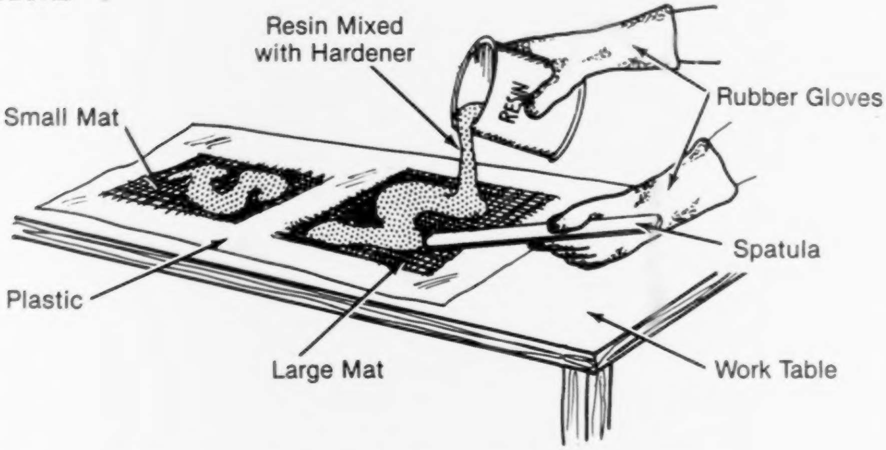
J. Lay a sheet of plastic on the workbench as shown in Figure 9

K. Lay the two fiberglass mats on the plastic and pour mixed resin over them (See Figure 9)

JOB SHEET #3

L. Using a spatula or putty knife, work resin back and forth on mats until they are thoroughly saturated (Figure 9)

FIGURE 9



M. Place larger mat on inside of panel, working it well into place and squeezing resin through it to help it stick to panel

N. Work out any air bubbles with spatula or putty knife, working from center to edges

O. Place smaller mat on larger piece on outside of panel, working it into place and removing air bubbles as for larger piece

P. Dispose of any unused resin/hardener in bucket of water

Q. Allow mats and resin/hardener to cure in place, forming base of repair

R. While mats are curing, clean putty knife or spatula and any mixing implements with lacquer thinner

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

S. Grind cured resin/hardener to scuff surface

T. Mix and apply plastic filler to damaged area on front of panel

(NOTE: Be sure to use plastic filler specifically designed for use on fiberglass. Instructions for mixing and applying plastic filler over fiberglass can be found in Section B, Unit V, "Body Filling," Job Sheet #2.)

U. Allow to cure for period of time recommended by manufacturer, and then grind to proper contour with 36-grit disc or 40-grit production paper

JOB SHEET #3

V. Finish sand, clean, and prime for painting as described in steps D through J in Job Sheet #1 procedure for repairing a surface crack

W. Clean work area, remove protective clothing, and return equipment and materials to proper storage

FIBERGLASS REPAIR
UNIT I

JOB SHEET #4 — REPAIR A SHATTERED FIBERGLASS PANEL

I. Equipment and materials

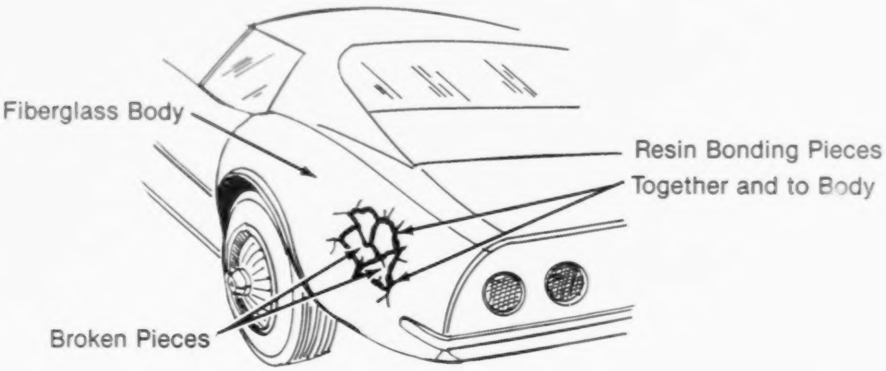
- A. Wax and grease remover
- B. Masking tape
- C. Body grinder or orbital sander
- D. 36-grit abrasive disc
- E. 40-grit and 60- or 80-grit production paper
- F. Tack cloth or air gun
- G. Clean cloths
- H. Heat gun or lamp if desired to speed curing time
- I. Fiberglass matting and cloth, resin, and hardener (epoxy resin may be used if desired)
- J. Plastic filler designed for use on fiberglass
- K. Small square of masonite, glass, or metal on which to mix plastic filler
- L. Putty knife or squeegee
- M. Scissors
- N. C-clamps or gripping pliers
- O. Unwaxed paper cup and mixing spatula
- P. Bucket of water
- Q. Lacquer thinner
- R. Protective clothing
  1. Rubber gloves or protective skin cream
  2. Eye protection
  3. Respirator and particle mask
  4. Headcover or hood

JOB SHEET #4

II. Procedure

(NOTE: Often the pieces from a wreck can be salvaged and put back together like a jigsaw puzzle to form a patch with which to repair a panel. This type of repair will not have the same strength as the rest of the panel, but will be adequate under most conditions. See Figure 10.)

FIGURE 10



A. Set up equipment and materials in a well-ventilated area

B. Put on protective clothing

C. Find and clean all salvaged pieces and damaged area

  1. Mask area around damage to protect undamaged finish

  2. Clean damaged area on back and front of panel, and clean backs and fronts of all damaged pieces with wax and grease remover; follow manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling fumes from wax and grease remover.

D. Find a piece that mates with main structure, and clamp into place with C-clamp or gripping pliers

E. Mix resin and hardener in unwaxed paper cup, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

JOB SHEET #4

F. Use putty knife or spatula to smear resin/hardener mixture on outer surface of panel over both main structure and patch piece, building a resin "bridge" over crack between main structure and piece (See Figure 10)

G. Repeat this process with each piece until all broken fragments have been glued together to form a roughly shaped basic structure as shown in Figure 10

H. Allow patch to cure and then remove clamps or pliers

I. Check assembly for rigidity, apply more resin to back of panel to reinforce if necessary

J. Use 36-grit disc to grind whole outer surface, removing high points and corners

(NOTE: This will leave a thin, weak shell, held together with resin but with no fiberglass fibers. A complete rebuild is now possible with fiberglass matting.)

K. Cut several small pieces of fiberglass matting to use for reinforcement

L. Saturate each piece with resin/hardener, and shingle over back of thin shell one at a time

(NOTE: Do not try to work with pieces that are too large.)

M. Carefully remove air bubbles after shingling is complete

N. Dispose of any unused resin/hardener in bucket of water

O. Allow mats and resin/hardener to cure in place while you clean putty knife or spatula and any mixing implements with lacquer thinner

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

P. Mix and apply plastic filler to damaged area on outside of panel

(NOTE: Be sure to use plastic filler specifically designed for use on fiberglass. Instructions for mixing and applying plastic filler over fiberglass can be found in Section B, Unit V, "Body Filling," Job Sheet #2.)

Q. Allow to cure for period of time recommended by manufacturer, and then grind to proper contour with 36-grit disc or 40-grit production paper

R. Finish sand, clean, and prime for painting as described in steps D through J in Job Sheet #1 procedure for repairing surface crack

S. Remove protective clothing, clean work area, and return equipment and materials to proper storage

FIBERGLASS REPAIR
UNIT I

JOB SHEET #5 — REPLACE A MISSING CURVED SECTION OF FIBERGLASS PANEL

I. Equipment and materials

- A. Wax and grease remover
- B. Masking tape and protective paper
- C. Paste floor wax
- D. Body grinder or orbital sander
- E. 36-grit abrasive disc
- F. 40-grit and 60- or 80-grit production paper
- G. Tack cloth or air gun
- H. Clean cloths
- I. Heat gun or lamp if desired to speed curing time
- J. Fiberglass matting, resin, and hardener (epoxy resin may be used if desired)
- K. Mold-making veil
- L. Plastic filler designed for use on fiberglass
- M. Small square of masonite, glass, or metal on which to mix plastic filler
- N. Fiberglass adhesive and accelerator
- O. Small inexpensive paintbrush with nylon bristles
- P. Putty knife or squeegee
- Q. Scissors
- R. Unwaxed paper cup and mixing spatula
- S. Bucket of water
- T. Lacquer thinner
- U. Plastic bag such as that used by dry cleaners
- V. Protective clothing
  1. Rubber gloves or protective skin cream
  2. Eye protection

JOB SHEET #5

3. Respirator and particle mask

4. Headcover or hood

II. Procedure

(NOTE: When a curved section of fiberglass is missing, it would be very difficult to lay fiberglass mat across the hole and properly reshape the area. In such a case, the body technician may make one of two choices: a new section can be purchased, or a mold core can be made. The following procedure outlines the steps that would be used to make a mold core.)

A. Find an undamaged vehicle of the make and model as that with missing piece

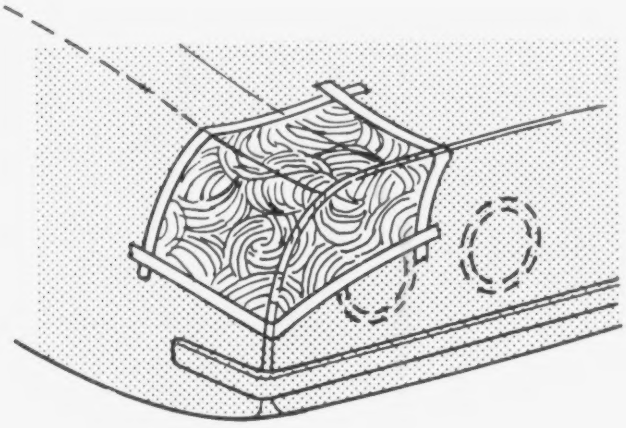
(NOTE: The vehicle may be found at a used car lot, salvage yard, or anywhere it may be used for an hour or so. It will not be harmed during the molding process. In this job sheet, a left, rear section of a Corvette is used as an example.)

B. Mark off mold area with strips of masking tape, making it slightly larger than damaged area on body being repaired (See Figure 11)

C. Using masking tape and paper, mask off areas outside tape to protect vehicle finish from spills

D. Smear mold area with a wet coat of paste floor wax (Figure 11)

FIGURE 11



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JOB SHEET #5

E. Cut mold-making veil into a number of small pieces, ranging from 2 inches by 4 inches to 4 inches by 6 inches

F. Put on rubber gloves and mix resin and hardener, following manufacturer's directions and cautions

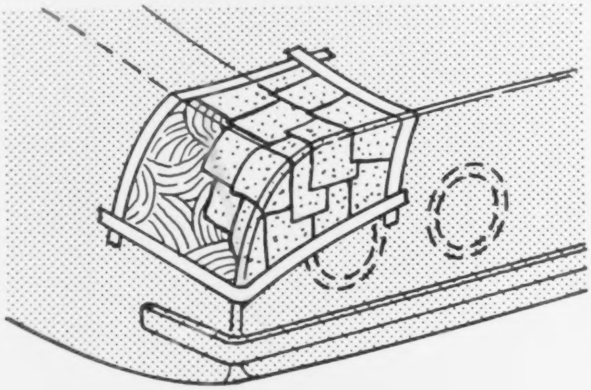
> **CAUTION**
>
> Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

G. Lay the small pieces of cut veil on plastic sheet, and use spatula or putty knife to spread resin/hardener mixture on them

H. Pick up small pieces with spatula and shingle them onto waxed surface (Figure 12)

(NOTE: Use smaller pieces of veil on the edges and around difficult curves. In all cases, use only *one* layer of veil.)

FIGURE 12



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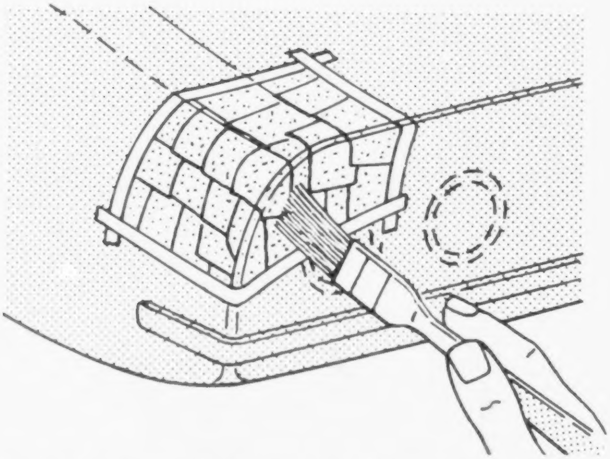
I. Wet paintbrush in resin and force veil into curves and around corners with ends of bristles (See Figure 13)

> **CAUTION**
>
> Do not brush back and forth or pieces will wrinkle or dislodge.

JOB SHEET #5

FIGURE 13



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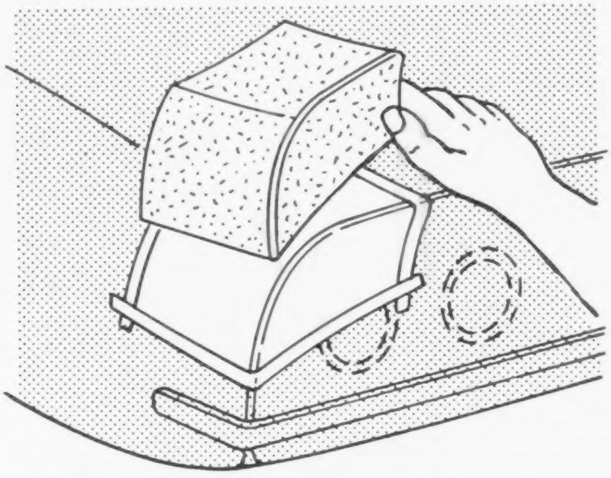
J. Continue shingling small pieces of veil onto waxed surface until entire surface has been covered with only one layer

K. Allow "shell" to cure for at least 1 hour

L. After shell has thoroughly cured, gently lift it away from original panel (Figure 14)

(NOTE: The shell—though slightly larger than the original area—will be an excellent reproduction of the panel.)

FIGURE 14



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JOB SHEET #5

M. Remove protective paper, tape, and wax from original panel; polish panel with a clean cloth

N. Cement shell under damaged panel on vehicle to be repaired (Figure 15)

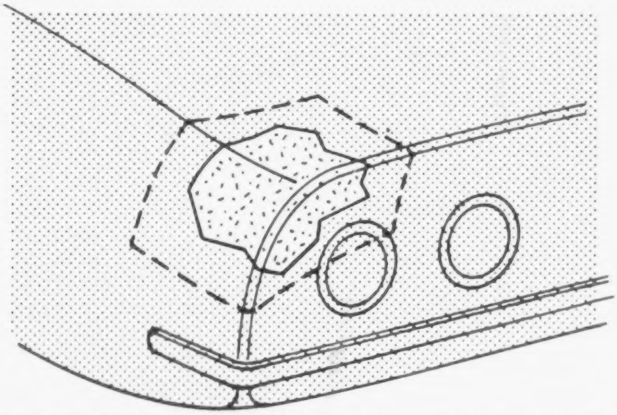
   1. Spray outer surface of shell with accelerator, following label instructions and cautions

   2. Spray same side of shell with adhesive

   3. Carefully align shell under damaged area on vehicle; apply firm pressure for a full minute to achieve a good bond

   4. Allow shell and panel to cure for period of time specified on adhesive label

FIGURE 15



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O. Put on protective clothing

P. Grind damaged edges on front of panel to a long taper, being careful not to damage shell

Q. Apply fiberglass matting to build area to original thickness

   1. Cut enough strips of fiberglass matting to build area slightly past desired contour

   2. Mix resin and hardener in unwaxed paper cup, following manufacturer's instructions and cautions

CAUTION

Wear rubber gloves or apply protective skin cream. Avoid inhaling toxic resin fumes.

JOB SHEET #5

3. Saturate fiberglass strips with resin/hardener mixture, either by brushing or immersing

4. Apply strips one at a time to outside of damaged panel on the taper and over the entire inner shell

5. Work out any air bubbles with putty knife, working from center to edges

6. Repeat steps 4 and 5 until desired contour is reached

7. Dispose of any unused resin/hardener mixture in bucket of water

8. Use heat lamp or heat gun to speed curing time if desired

9. While matting and resin/hardener material cures, clean putty knife and any mixing implements with lacquer thinner

CAUTION

Lacquer thinner is highly explosive. Do not expose to heat or flame.

10. Grind to proper contour with 36-grit disc or 40-grit production paper

11. Use air gun to clean surface of grinding dust particles

R. Mix and apply plastic filler to repair area on front of panel

(NOTE: Be sure to use plastic filler specifically designed for use on fiberglass. Instructions for mixing and applying plastic filler over fiberglass can be found in Section B, Unit V, "Body Filling," Job Sheet #2.)

S. Allow to cure for period of time recommended by manufacturer, and then grind to proper contour with 36-grit disc or 40-grit production paper

T. Finish sand, clean, and prime for painting as described in steps D through J in Job Sheet #1 procedure for repairing surface scratches

U. Clean work area, remove protective clothing, and return equipment and materials to proper storage

ABR - 39-C

FIBERGLASS REPAIR
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with fiberglass repair. Write the correct numbers in the blanks.

______a. Agent that bonds well with both fiberglass and metal

______b. Loosely woven, thin strands of fiberglass used to repair minor damage

______c. Drying and hardening of fiberglass resin

______d. Agent that bonds only with fiberglass

______e. Catalyast that speeds curing time of resin mixture

______f. Overlapped as roofing materials on a house

______g. To grind to an angle

______h. Molten glass that has been drawn out into tiny threadlike fibers

______i. Powdered fiberglass and polyester resin

______j. To soak fiberglass cloth or mat with resin/hardener mixture

______k. Process of drilling a small hole at each end of a crack to prevent crack from spreading

______l. Tightly woven, thick strands of fiberglass used to repair major damage

______m. Very fine fiberglass cloth used to shape repair part

______n. Time required for thinner to evaporate from surface

1. Fiberglass
2. Fiberglass mat
3. Fiberglass cloth
4. Flash time
5. Mold-making veil
6. Bevel
7. Fiberglass filler
8. Polyester resin
9. Epoxy resin
10. Curing
11. Hardener
12. Saturate
13. Shingled
14. Stop drilling

TEST

2. List four advantages of fiberglass auto-body construction.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

3. State three ways in which fiberglass repairs differ from metal or plastic repairs.

a. ____________________

____

b. ____________________

____

c. ____________________

____

4. Select from the following list guidelines for proper repair of fiberglass panels and parts. Write an "X" in the blank before each correct answer.

_____a. Analyze damage to determine cost of repair

_____b. Thoroughly clean inner and outer surfaces of panel

_____c. Remove loose or broken panel from vehicle

_____d. Mask damaged area to reinforce repair

_____e. Rough sand and bevel edges to ensure good adhesion

_____f. Reconstruct damaged area from outside to inside when possible

_____g. Thoroughly saturate cloth or mat with resin/hardener and work out all air bubbles

_____h. Build the repair, applying cloth or mat in layers

_____i. Allow time for resin/hardener to cure before applying to cloth or mat

TEST

5. Complete the following safety precautions to observe when working with fiberglass. Write the correct word or words in the blanks.

   a. Always wear ________ ________ when handling resin or fiberglass

   b. Wear respirator, ________ , and safety glasses; ________ ________ collar and shirt sleeves; and secure shirt sleeves with ________ around cuffs when grinding or sanding fiberglass.

   c. Carry out all repair procedures in a ________ - ________ area so that exhaust system can draw out toxic ________ ________

   d. Keep an appropriate ________ ________ nearby at all times

   e. Mix only amount of resin and hardener ________ , and dispose of any unused resin/hardener by dropping it into a ________ of ________

   f. Read *all* ________ and ________ ________ on fiberglass repair products before using product

   g. Remove any resin deposits on ________ or ________ with ________ ________ before resin jells or hardens

   h. Use ________ ________—highly flammable substances—with the greatest care and caution

(NOTE: Test item 6 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

6. Demonstrate the ability to

   a. Repair minor surface damage to a fiberglass panel.

   b. Repair a crack in a fiberglass panel.

   c. Repair a puncture in a fiberglass panel.

   d. Repair a shattered fiberglass panel.

   e. Replace a missing curved section of fiberglass panel.

FIBERGLASS REPAIR
UNIT I

ANSWERS TO TEST

1. a. 9
   b. 3
   c. 10
   d. 8
   e. 11
   f. 13
   g. 6
   h. 1
   i. 7
   j. 12
   k. 14
   l. 2
   m. 5
   n. 4

2. Answer should include any four of the following

   a. Possesses extraordinary strength
   b. Is very durable
   c. Is highly resistant to fire
   d. Will not rust or corrode
   e. Is completely waterproof
   f. Is lightweight and never rattles
   g. Damage tends to be localized close to point of impact rather than spread over wide area of panel as with sheet-metal collision damage

3. Answer should include any three of the following

   a. Fiberglass does not stretch or give and thus cannot be worked with tools as can metal
   b. Fiberglass cannot be welded, molded, or shaped with heat as can plastic or metal
   c. Because fiberglass cannot be worked or shaped, damaged material must be removed and area reinforced, patched, or replaced
   d. Raised fiberglass areas cannot be tapped down as can raised metal areas, so fiberglass repairs are applied from inside to outside when possible

4. b, e, g, h

5. a. Rubber gloves
   b. Hood, button up, rubberband
   c. Well-ventilated, resin fumes
   d. Fire extinguisher
   e. Needed, bucket, water
   f. Instruction, caution labels
   g. Hands, tools, lacquer thinner
   h. Lacquer thinners

6. Performance skills evaluated to the satisfaction of the instructor

PLASTIC REPAIR
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and repair damage to types of thermoset and thermoplastic plastics used in auto-body construction. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with plastic repair.
2. Distinguish between characteristics of thermoset and thermoplastic plastics.
3. Identify national identification symbols for plastics.
4. Identify weldable plastics given their burning characteristics.
5. Match the five most common auto-body plastics to their principal applications.
6. List basic auto-body plastic repair techniques.
7. Match the most commonly used auto-body plastics to their specific repair procedures.
8. Label the parts of a hot-air (plastic) welder.
9. Match hot-air welding tips to their correct uses.
10. List guidelines for achieving quality hot-air welds.
11. Match welding rod color codes to the plastic for which each is intended.
12. Demonstrate the ability to
    a. Perform burn tests and melt tests to identify plastics.
    b. Adhesive bond a minor tear or crack.
    c. Chemically bond a puncture.
    d. Chemically bond an outer-edge tear.
    e. Hot-air weld a minor tear or crack.
    f. Hot-air weld a long, straight crack.
    g. Hot-air weld a replacement piece for a broken plastic part or torn bolt hole.

PLASTIC REPAIR
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Supplements

      1. Supplement #1 — Thermoplastic Plastics Welding Guide

      2. Supplement #2 — Welding Rod Color Coding by Supplier

   D. Information sheet

   E. Job sheets

      1. Job Sheet #1 — Perform Burn Tests and Melt Tests to Identify Plastics

      2. Job Sheet #2 — Adhesive Bond a Minor Tear or Crack

      3. Job Sheet #3 — Chemically Bond a Puncture

      4. Job Sheet #4 — Chemically Bond an Outer-Edge Tear

      5. Job Sheet #5 — Hot-Air Weld a Minor Tear or Crack

      6. Job Sheet #6 — Hot-Air Weld a Long, Straight Crack

      7. Job Sheet #7 — Hot-Air Weld a Replacement Piece for a Broken Plastic Part or Torn Bolt Hole

   F. Test

   G. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials to supplement unit.

      1. Filmstrip "Plastic Welding," from series *Autobody Fiberglass and Plastic Repairs*

         (NOTE: This filmstrip is a part of a series of five filmstrips, five cassettes, and program guide available from Prentice-Hall Media, ServCode DU, 150 White Plains Road, Tarrytown, New York 10591.)

      2. Hot-air welder and various tips for demonstration purposes

SUGGESTED ACTIVITIES

3. Auto-body parts of various types of plastic
4. Assorted welding rods from different manufacturers
5. Equipment and materials for job sheet procedures
6. Competency profiles

   (NOTE: Competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss unit and specific objectives.
- Explain that in recent years more and more plastic has been used in various parts of vehicle bodies, particularly in the front end. Because the parts are much lighter in weight than sheet metal, they have become an important part of every United States manufacturer's fuel-saving, weight-reduction program. All signs indicate that plastic body parts are here to stay. Therefore, plastic repairs can be expected to be a growing part of the workload in every body shop.
- Explain that many plastic parts can be repaired more economically than they can be replaced. Cuts, cracks, gouges, tears, and punctures are all repairable; and when necessary, some plastics can also be reformed after distortion from their original shapes.

E. Discuss information and job sheets.

1. Use information Sheet, Section I to introduce students to terms and definitions associated with plastic repair.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss the differences between and characteristics of thermoset and thermoplastic plastics.

   SUGGESTIONS:

   - Show students examples of both classes of plastic.
   - Explain that plastics made of thermosetting resin cannot be welded. These plastics are permanently shaped when they are molded or during the curing process and cannot be reheated or reshaped. They can, however, be bonded with special adhesives.

SUGGESTED ACTIVITIES

3. Use Information Sheet, Section III to introduce students to national identification symbols for plastics.

   SUGGESTIONS:

   - Explain that national identification symbols are not yet being universally applied by plastics manufacturers, but that when the plastic is stamped with its symbol, the symbol will generally be found on the back of the plastic part.
   - Encourage students to memorize the symbols. Make a set of flashcards to aid memorization and for review.

4. Use Information Sheet, Section IV to discuss the burning characteristics of weldable plastics.

   SUGGESTIONS:

   - Demonstrate burning characteristics by performing the burn test on each of the types of thermoplastic plastics.
   - Encourage students to memorize the characteristics of each type of thermoplastic. Make a set of flashcards to aid memorization and for review.
   - Have students complete Job Sheet #1.

5. Use Information Sheet, Section V to explain the principal applications of common auto-body plastics.

   SUGGESTIONS:

   - Show students plastic parts on various makes and models of vehicles.
   - Have students identify the type of plastic used for parts on various makes and models of vehicles.

6. Use Information Sheet, Sections VI and VII to discuss general and specific repair procedures used on auto-body plastics

   SUGGESTIONS:

   - Demonstrate procedures outlined in Job Sheets #2 through #4.
   - Have students complete Job Sheets #2 through #4.

7. Use Information Sheet, Sections VIII and IX to introduce students to the parts of a hot-air welder and uses for each type of welding tip.

   SUGGESTIONS:

   - Show students a hot-air welder and have them name each part.

SUGGESTED ACTIVITIES

- Demonstrate the correct use for each hot-air welding tip. Allow students to practice using each tip.

8. Use Information Sheet, Sections X and XI to discuss welding rod selection, and guidelines for achieving quality hot-air welds.

   - Show film "Plastic Welding" from series *Autobody Fiberglass and Plastic Repairs.*
   - Provide students with copies of Supplements #1 and #2.
   - Demonstrate the correct use of the hot-air welder.
   - Show students assorted welding rods from various manufacturers.
   - Demonstrate procedures outlined in Job Sheets #5 through #7. Allow students to practice procedures on scrap plastic before completing the job sheets.
   - Have students complete Job Sheets #5 through #7.

III. Unit references

A. "Automotive Plastics: Cheap Substitute or Advance Replacement Product?" Inter-industry Conference on Auto Collision Repair, sponsored by Ford Motor Company, n.d.

B. *Repairing Plastic Body Parts: A Technical Orientation Handbook.* Inter-industry Conference on Auto Collision Repair, sponsored by Ford Motor Company, n.d.

C. Rhone, L.C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: The Bobbs-Merrill Company, Inc. 1983.

SUGGESTED ACTIVITIES

SUPPLEMENT #1 — THERMOPLASTIC PLASTICS WELDING GUIDE

Plastic	Symbol	Auto body applications	Identification	Recommended pressure (psi)	Recommended temperature (°F)
Polyurethane	PUR TPUR	Bumper covers	Flexible; burns with yellow-orange flame that sputters	4	500
Polypropylene	PP	Fender aprons Fan shrouds Heater housings Trim panels	Bendable; burns with no visible smoke	3	575
Polyethylene	PE	Holding tanks Trim panels	Flexible; feels like wax; burns with a smell like burning wax; drips when burning	3	550
ABS	ABS	Grills Dash panels Interior trim	Rigid; burns with black, sooty smoke	3	500
Polyvinyl chloride	PVC	Bumper fillers Crash pads Vinyl sheeting	Flexible; chars and gives off grey smoke	3	525

SUGGESTED ACTIVITIES

SUPPLEMENT #2 — WELDING ROD COLOR CODING BY SUPPLIER

Plastic	Rod Suppliers			
	Seelye	Laramy	Hejet	Karman-Aire
Polyurethane	Yellow	Translucent	Clear	Yellow
Polypropylene	Black	Black	Frosted clear	Clear or black
Polyethylene	Brown	Dark grey	White	Brown
ABS	Blue	Ivory	Black	Ivory or blue
Polyvinyl chloride	Light grey	Light grey	Grey	Grey

PLASTIC REPAIR
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Polymerization — Process of joining two or more like molecules to form a more complex molecule of different physical properties

B. Catalyst — Substance or agent that speeds up or sometimes slows down a chemical reaction

EXAMPLES: Acid, heat, or ultraviolet rays act as a catalyst in the polymerization process.

C. Corrosive — Capable of eating into or wearing away as by rusting or the action of chemicals

D. Hot-air welding — Process of using an electrically heated, hot-air torch to soften and fuse base plastic and welding rod plastic

E. Translucent — Letting some light shine through; partially transparent

F. Tensile strength — Greatest lengthwise stress a given substance can bear without tearing apart

G. Durable — Lasting despite hard wear or frequent use

H. Accelerator — Catalyst that speeds up curing time of adhesive

I. Juicing — Moist appearance along sides of a weld

II. Characteristics of thermoset and thermoplastic plastics

(NOTE: There are two families or classes of plastics: thermoset and thermoplastic. The prefix *thermo* in both of these terms refers to heat. The root *set* in the term *thermoset* means "fixed" or incapable of being molded, shaped, or re-formed. The root *plastic* in the term *thermoplastic* means "flexible" or capable of being molded, shaped, or re-formed.)

A. Thermoset plastic — Class of plastic polymerized into a molecular structure that cannot later be changed either by heat or chemicals; not weldable

EXAMPLES: Thermoset polyurethane, polyester (fiberglass)

B. Thermoplastic plastic — Class of plastic having a molecular structure capable of being changed by chemicals, heating, or cooling; weldable

EXAMPLES: Thermoplastic polyurethane, polypropylene, polyvinyl chloride (vinyl)

INFORMATION SHEET

III. National identification symbols for plastics (Table 1)

(NOTE: The auto body technician must not only be able to distinguish between thermoset and thermoplastic plastics, but must also be able to identify the different types of weldable thermoplastics in order to select the correct repair procedure and welding rod. While national identification symbols are often found on parts to be repaired, sometimes these parts are not identified by these symbols. In such cases, the technician must identify the plastic through burn tests.)

TABLE 1: Plastic identification symbols

Thermoplastic plastics	
ABS	Acrylonitrile butadiene styrene
ABS/PVS	ABS vinyl
EPDM	Ethylene propylene diene monomer
PA	Nylon
PC	Lexan
PE	Polyethylene
PP	Polpropylene
PPO	Noryl
PVC	Polyvinyl chloride (vinyl)
TPR	Thermoplastic rubber
TPUR	Thermoplastic polyurethane
Thermoset plastics	
PUR	Thermoset polyurethane
UP	Polyester (fiberglass)

INFORMATION SHEET

IV. Burning characteristics of weldable plastics (Table 2)

TABLE 2: Burning characteristics of weldable plastics

Type of plastic	Characteristcs
Polypropylene	Burns with no visible smoke Has its own distinguishing smell Continues to burn when flame is removed
Polyethylene	Melts, swells, and drips Drippings may burn Smells like burning wax Continues to burn when flame is removed
ABS	Burns with thick, black, sooty smoke that hangs in air Has its own distinguishing smell Continues to burn when flame is removed
Polyvinyl	Chars and gives off grey smoke Has its own distinguishing smell Is self-extinguishing
Polyurethane	Burns with yellow-orange flame and black smoke Flame sputters Continues to burn when flame is removed

V. Principal applications of the five most common auto body plastics

A. Polyurethane — Bumper covers

(NOTE: Thermoset polyurethane is used by the majority of vehicle manufacturers. Bumper covers on pre-1980 General Motors vehicles are made of thermoplastic polyurethane.)

B. Polypropylene

1. Inner aprons
2. Fan shrouds
3. Splash panels
4. Heater housing ducts
5. Trim panels
6. Rigid seat parts

INFORMATION SHEET

- C. Polyethylene
  - 1. Holding tanks
  - 2. Trim panels
- D. Acrylonitrile butadiene styrene
  - 1. Grills
  - 2. Dash panels
  - 3. Rigid interior trim
- E. Polyvinyl chloride
  - 1. Vinyl sheeting in tops and seats
  - 2. Some bumper fillers and crash pads

VI. Basic auto body plastic repair techniques

- A. Adhesive bonding (cement)
- B. Chemical bonding (structural adhesive)
- C. Hot-air welding

VII. Specific repair procedures for the most commonly used auto-body plastics

- A. Thermoset polyurethane
  - 1. Use heat to repair dents
  - 2. Bond with cement or fill with structural adhesive
  - 3. Reinforce with fiberglass mat on large tears
  - 4. Sand smooth and paint
- B. Thermoplastic polyurethane
  - 1. Use heat to repair dents
  - 2. Hot-air weld tears
  - 3. Bond with cement or fill with structural adhesive
  - 4. Sand smooth and paint

INFORMATION SHEET

C. Polyproplene

1. Use heat to repair dents
2. Hot-air weld
3. Sand weld for appearance
4. Finish with flat black or undercoat on aprons, or with plastic paint on trim panels

D. Polyethylene

1. Hot-air weld
2. Sand welds for appearance
3. Paint or undercoat for uniform finish if desired

   (NOTE: If polyethylene is painted or undercoated, its translucent appearance is lost.)

E. Acrylonitrile butadiene styrene

1. Hot-air weld
2. Sand welds for appearance
3. Fill with paste of MEK (methyl ethyl ketone) and ABS plastic, or with structural adhesive
4. Refinish as required

F. Polyvinyl chloride

1. Hot-air weld
2. Trim and/or sand weld
3. Refinish as required

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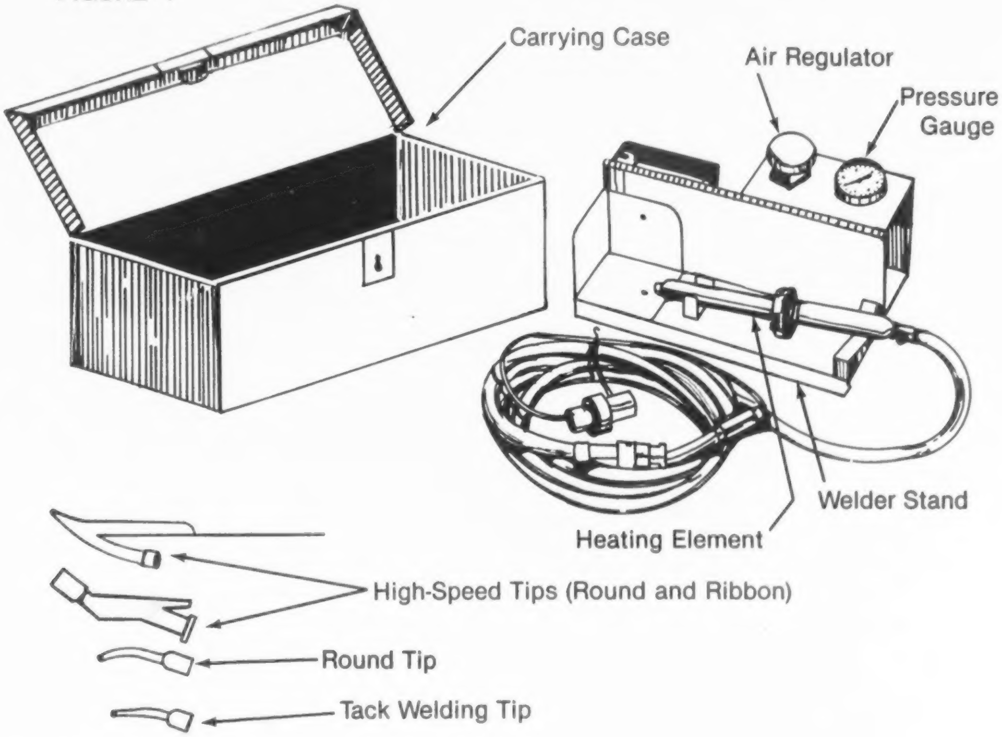
VIII. The parts of a hot-air welder (Figure 1)

FIGURE 1



IX. Uses of hot-air welding tips

A. Tack-welding tip — Used to align and temporarily hold in place a torn or split panel

B. Round tip — Used for general welding and for damaged parts that have hard-to-reach areas, tight, sharp corners, or small holes

C. High-speed tip — Used for automatic feed-tip operation and fast, one-handed welding of long, straight cracks

X. Guidelines for achieving quality hot-air welds

A. Use recommended pressure for plastic being welded (See Table 3)

(NOTE: Use air only; never use oxygen or other flammable gases.)

B. Select correct temperature for plastic being welded (See Table 3)

(NOTE: Neither the rod nor the base material should char or discolor, and the welding rod should hold its basic round shape.)

INFORMATION SHEET

EXAMPLE:

TABLE 3: Plastic welding guide

Plastic	Pressure (psi)	Temperature (°F)
Polyurethane	4	500
Polypropylene	3	575
Polyvinyl chloride	3	525
Polyethylene	3	550
ABS	3	500

C. Choose a rod length that matches that of the weld; never stretch rod over weld

D. Hold both tip and rod at correct angle

E. Keep downward pressure on rod at all times to achieve a good bond

(NOTE: On most plastics, a weld that is properly bonded *cannot* be pulled apart, even when hot.)

F. Apply at a steady speed that allows juicing to occur along each side of weld

XI. Color codes for welding rod selection and identification

(NOTE: The welding rod used must be of the same type of plastic as the base material to be welded. To simplify identification, rods are color coded as listed below. This color coding is common but not universal; therefore, the technician may have to perform a melt test for positive rod identification.)

A. Yellow/clear — Polyurethane

B. Black — Polypropylene

C. Blue — ABS

D. Light grey — Polyvinyl chloride

E. Brown — Polyethylene

PLASTIC REPAIR
UNIT II

JOB SHEET #1 — PERFORM BURN TESTS AND MELT TEST TO IDENTIFY TYPES OF PLASTIC

I. Equipment and materials

   A. Various auto body plastic parts

   B. Color-coded welding rods

   C. Pliers

   D. Matches

   E. Gloves

   F. Eye protection

II. Procedure

   A. Determine class of plastic

      1. Put on gloves and eye protection

      2. Hold lighted match 1 inch from each piece of material for 10 seconds

      3. If softening or melt occurs, the material is thermoplastic; set aside for burn and melt tests

      4. If softening or melt does not occur, the material is thermoset and cannot be welded

   B. Perform burn test

      1. Remove a silver of plastic from back of part

      2. Hold silver with pliers and ignite plastic

      3. Observe the burning plastic and compare to characteristics in Table 4 on next page

JOB SHEET #1

TABLE 4: Burning characteristics of weldable plastics

Type of plastic	Characteristics
Polypropylene	Burns with no visible smoke Has its own distinguishing smell Continues to burn when flame is removed
Polyethylene	Melts, swells, and drips Drippings may burn Smells like burning wax Continues to burn when flame is removed
ABS	Burns with thick, black, sooty smoke that hangs in air Has its own distinguishing smell Continues to burn when flame is removed
Polyvinyl	Chars and gives off grey smoke Has its own distinguishing smell Is self-extinguishing
Polyurethane	Burns with yellow-orange flame and black smoke Flame sputters Continues to burn when flame is removed

4. Confirm your test by comparing the odor of the sample part to the odor of ignited color-coded rod

C. Perform melt test

1. Melt a small sample area on hidden side of plastic part, along with rod you think is correct
2. Hold rod against surface briefly, and then pull to test bond; an incompatible rod will pull away with no adhesion

D. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #2 — ADHESIVE BOND A MINOR TEAR OR CRACK

I. Equipment and materials

   A. Masking tape

   B. Wax and grease remover

   C. Clean cloth

   D. Bonding adhesive and accelerator

   E. Rubber gloves

   F. Eye protection

II. Procedure

   A. Remove damaged component from vehicle, or mask area adjacent to damage as necessary

   B. Set up equipment and materials in well-ventilated work area

   C. Read instructions and cautions on wax and grease remover label

   D. Put on eye protection and rubber gloves

   E. Wipe repair area clean with wax and grease remover, following manufacturer's application instructions

CAUTION

Avoid inhaling the fumes from the wax and grease remover or from any of the products used to bond plastic.

(NOTE: In all plastic repair procedures it is important for the mating surfaces to be clean and free of wax, dust, or grease.)

   F. Spray on side of tear or crack with accelerator, following label instructions and cautions

   G. Apply adhesive to same side of crack

   H. Carefully position two edges of tear or crack in their original position. and quickly press them together with firm pressure

   I. Hold edges together for a full minute to achieve good bond strength

JOB SHEET #2

J. Cure for 3 to 12 hours for maximum strength, according to instructions on adhesive label

K. If original paint was not damaged and repair was properly positioned, painting may not be required

L. If painting is required, special procedures are needed and must be carefully followed; refer to vehicle manufacturer's technical publications

M. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #3 — CHEMICALLY BOND A PUNCTURE

I. Equipment and materials

   A. Masking tape

   B. Wax and grease remover

   C. Clean cloth

   D. Pistol grip grinder or 1/4-inch drill motor

   E. 2-inch or 3-inch grinding disc

   F. 5-inch or 6-inch sanding disc

   G. Portable propane torch (or any torch with a controlled flame)

   H. Flight striker

   I. Aluminum foil backing

   J. Structural adhesive kit

   K. Small square of masonite, glass, or metal on which to mix adhesive

   L. Heat lamp or gun

   M. Flexible squeegee or spatula

   O. Particle mask

   P. Rubber gloves

   Q. Eye protection

II. Procedure

   A. Locate vehicle and set up equipment and materials in a well-ventilated area

   B. Mask undamaged area adjacent to puncture

   C. Read instructions and cautions on wax and grease remover label

   D. Put on eye protection

JOB SHEET #3

E. Wipe repair area clean with wax and grease remover, following manufacturer's application instructions.

> **CAUTION**
>
> Avoid inhaling the fumes from the wax and grease remover, or from any of the products used to bond plastic.

(NOTE: In all plastic repair procedures, it is important for the mating surfaces to be clean and free of wax, dust, or grease.)

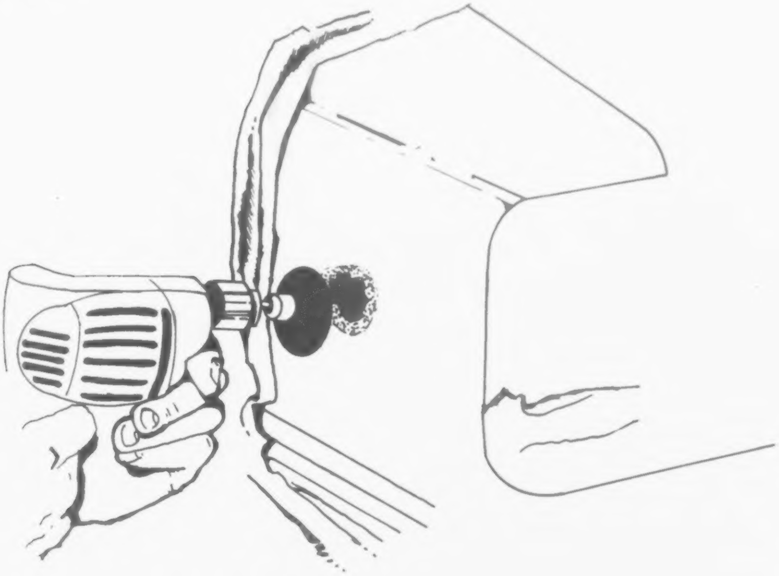
F. Take off rubber gloves

G. Prepare damaged area for structural adhesive

1. Equip grinder or 1/4-inch drill motor with small grinding disc; connect to power source
2. Put on particle mask
3. Bevel edges of puncture back about 1/4 to 3/8 inch, beveling around full diameter of hole (Figure 2)

   (NOTE: Beveling leaves a coarse surface for good adhesion. In any repair, the mating surfaces should be scuffed to improve adhesion.)

FIGURE 2



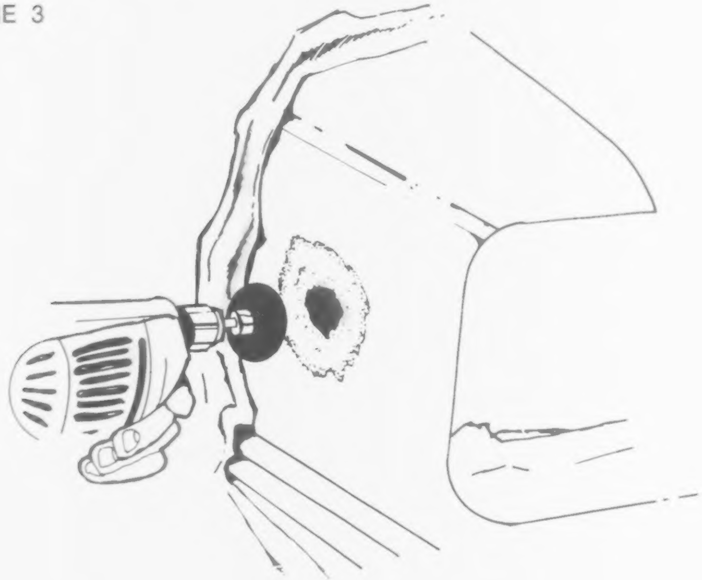
JOB SHEET #3

4. Disconnect grinder or drill motor from power source and replace disc with a finer grit disc

5. Connect grinder or drill motor to power source, and featheredge paint around repair area, taking care to remove paint but very little plastic

6. Continue removing paint until you have a paint-free band around the puncture about 1 to 1½ inches wide (Figure 3)

FIGURE 3



7. Carefully wipe off all paint and plastic dust; the repair area must be absolutely clean

8. Remove particle mask, and clear work area of wax and grease remover, structural adhesive, or any other flammable or explosive material

9. Light propane torch with striker, and adjust flame to a 1 inch cone tip

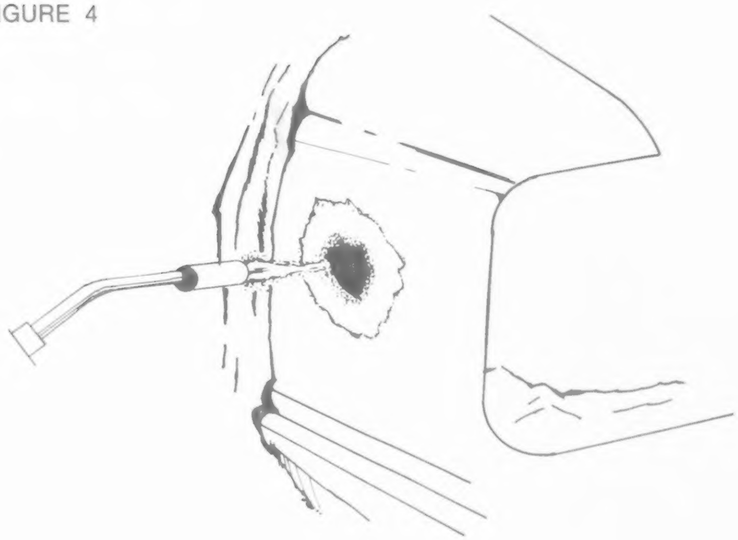
10. Very carefully direct flame onto beveled area of puncture, moving flame all the time, until beveled area is slightly brown (See Figure 4)

CAUTION

Use extreme care to avoid warping the plastic or burning the paint.

JOB SHEET #3

FIGURE 4

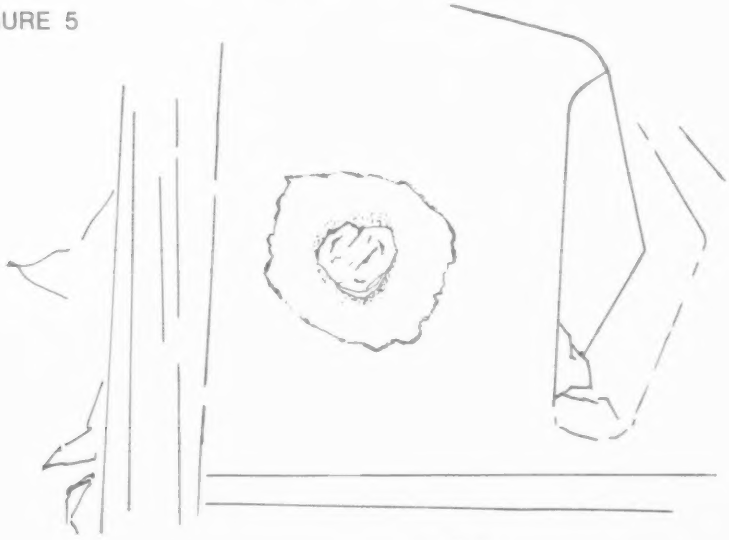


11. Turn off torch, put on rubber gloves, and clean *inner* surface of repair area with wax and grease remover

    (NOTE: Partial disassembly may be necessary to reach the inner surface of the panel.)

12. Remove rubber gloves, and install foil backing tape on *inner* side of panel, covering puncture completely and allowing about 1 inch adhesion surface around edges (Figure 5)

FIGURE 5



JOB SHEET #3

H. Put on rubber gloves and mix equal parts of plastic components in structural adhesive kit for about 2 minutes

   1. Mix by stirring or kneading, not by beating the material

   2. Discontinue mixing when structural adhesive has a uniform color

I. Paddle the mixed adhesive into puncture hole, using applicator that comes with kit; fill bottom of hole and do not worry about contour at this time

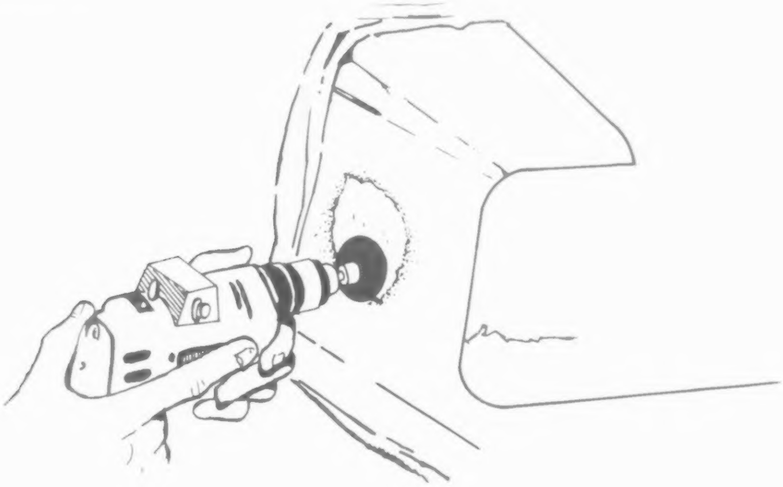
   (NOTE: This step must be performed carefully and quickly, as the structural adhesive mixture will begin to set up in about 2 to 3 minutes.)

J. Cure first application for about 20 minutes with heat gun or lamp at 190°F to 220°F

K. Equip grinder or drill motor with small, fine-grit grinding disc; connect to power source

L. Put on particle mask and grind down high spots of first structural adhesive application (Figure 6)

FIGURE 6



JOB SHEET #3

M. Disconnect grinder or drill motor

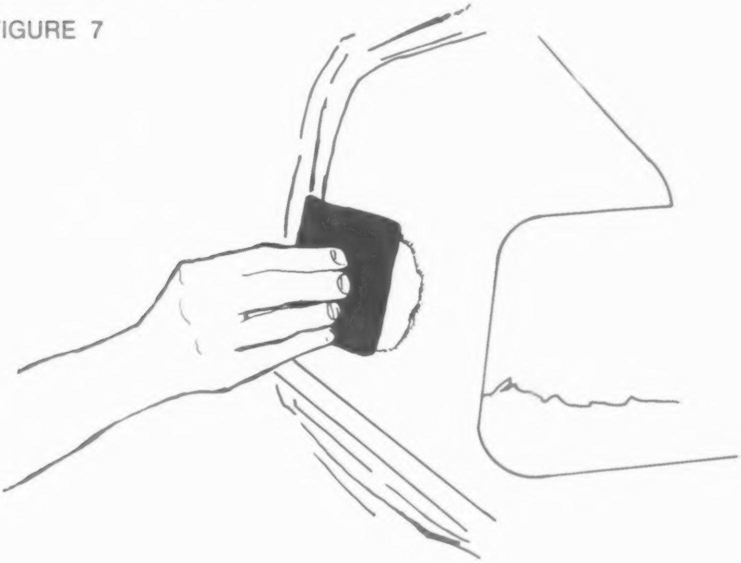
N. Wipe dust from repair area

O. Remove particle mask, put on rubber gloves, and mix second application of adhesive, mixing components together as before for about 2 minutes

P. Apply second adhesive mixture in thin layers, building it to an overfill contour of the area

(NOTE: A flexible squeegee or spatula is useful in approximating the panel contours. See Figure 7.)

FIGURE 7



Q. Cure second application for about 20 minutes with heat gun or lamp at 190°F to 220°F

R. Finish grind patch down to original contour of panel, using larger grinding disc and finer grit abrasive

(NOTE: If pops, pits, or low spots are found, they may be filled with additional small batches of adhesive. The puncture is now repaired and the surface is ready for the disc or block sanding necessary for paint.)

S. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #4 — CHEMICALLY BOND AN OUTER-EDGE TEAR

I. Equipment and materials

   A. Masking tape

   B. Wax and grease remover

   C. Clean cloth

   D. Pistol-grip grinder or ¼-inch drill motor

   E. 2-inch or 3-inch grinding discs

   F. 5-inch or 6-inch sanding disc

   G. Bonding adhesive and accelerator

   H. Structural adhesive kit

   I. Small square of masonite, glass, or metal on which to mix adhesive

   J. Heat lamp or gun

   K. Scissors or razor-blade knife

   L. Particle mask

   M. Rubber gloves

   N. Eye protection

II. Procedure

   (NOTE: In the case of tears that extend through the outer edge of the plastic, a simple repair with bonding adhesive may not be strong enough, and the application of a backing strip is recommended.)

   A. Interpret national identification symbol or perform burn test to determine class and type of plastic to be mended (Job Sheet #1)

   B. Cut from scrap plastic a small piece of the same type of plastic to use as a patch

   C. Put on eye protection

   D. Equip grinder or drill motor with small, medium-grit disc; connect to power source

JOB SHEET #4

E. Put on particle mask and bevel *front* edges of the two sides of tear

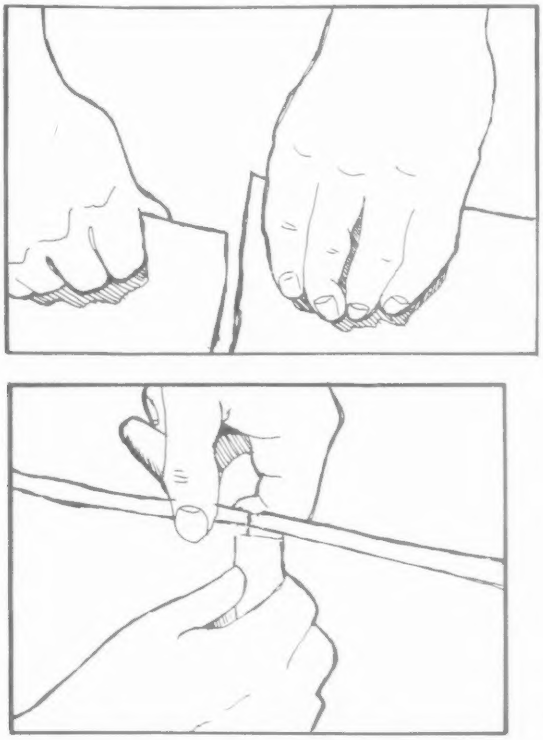
F. Disconnect grinder or drill motor from power source, remove particle mask, and put on rubber gloves

G. Wipe back of tear clean with wax and grease remover, following manufacturer's application instructions

> **CAUTION**
>
> Avoid inhaling the fumes from the wax and grease remover or from any of the products used to bond plastic.

H. Align the two edges of tear, and adhesive bond the small plastic patch to *back* of tear across end (Figure 8)

FIGURE 8



I. Mix equal parts of plastic components in structural adhesive kit for about 2 minutes

1. Mix by stirring or kneading, not by beating the material
2. Discontinue mixing when structural adhesive is a uniform color

J. Paddle mixed adhesive onto tear, using applicator that comes with kit

(NOTE: This step must be performed carefully and quickly, as the structural adhesive mixture will begin to set up in 2 to 3 minutes.)

JOB SHEET #4

K. Cure and finish as outlined in Job Sheet #3

L. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #5 — HOT-AIR WELD A MINOR TEAR OR CRACK

I. Equipment and materials

A. Hot-air welder

B. Tack-welding and round hand-welding tips

C. Color-coded welding rods

D. Matches

E. Hand rotary grinder or small rotary file and medium-grit abrasive

F. Knife or clippers

G. Wax and grease remover

H. Clean cloth

I. Cutting pliers

J. Particle mask

K. Rubber gloves

L. Eye protection

M. Masking tape

II. Procedure

A. Use national identification symbol or burn test to determine class and type of damaged plastic

B. Use color coding or melt test to select proper welding rod

C. Mask off area adjacent to damage as necessary

D. Put on eye protection and rubber gloves

E. Read instructions and cautions on wax and grease remover label

F. Wipe repair area clean with wax and grease remover, following manufacturer's application instructions

JOB SHEET #5

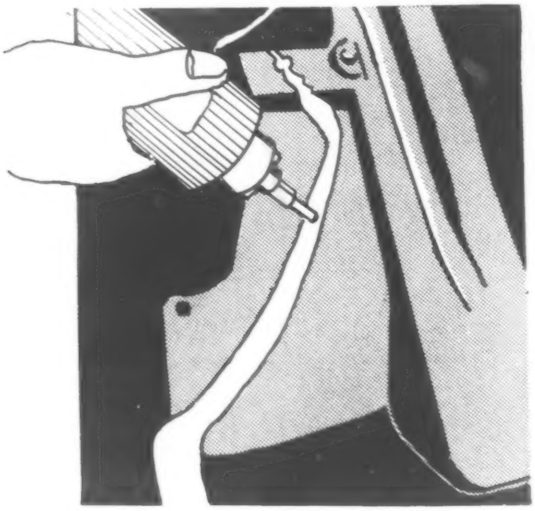
CAUTION

Avoid inhaling the fumes from the wax and grease remover, or from any of the products used on bond plastic.

G. Remove rubber gloves, put on particle mask, and use hand rotary grinder or small rotary file to bevel edges of tear or crack (Figure 9)

(NOTE: Beveling provides a clean surface for the weld and increases the surface area for adhesion of the welding rod. Beveling may be made on the front or on the front and back of the weld. Front beveling [single V] is used for relatively thin material or when access to the reverse side is limited. Front and back beveling [double V] is used with thicker materials and requires less filling.)

FIGURE 9



H. Clean tear or crack of all dust; surface must be absolutely clean for welding

I. Remove particle mask

J. Fit welder with tack-welding tip

K. Connect welder to power source and select correct temperature and pressure for type of plastic to be welded

L. Align torn or cracked edges of panel; hold together while pressing hot welder tip against plastic

JOB SHEET #5

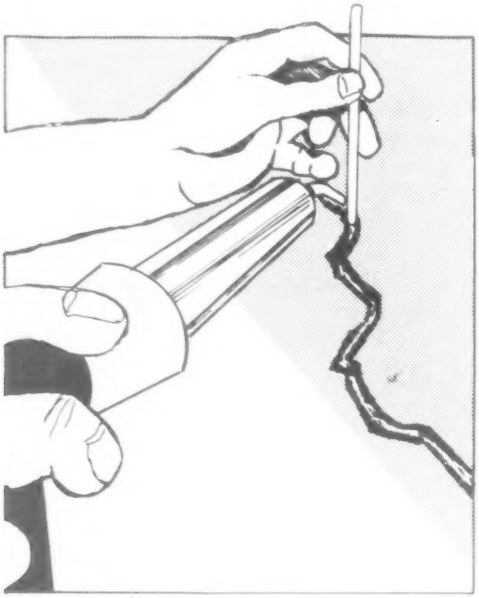
M. Tack-weld along entire length of damage to fuse edges in correct position

(NOTE: All weldable plastics except polyurethane can be tack-welded in this manner. Polyurethane is usually better aligned with tape or bonding adhesive.)

N. Weld damaged area

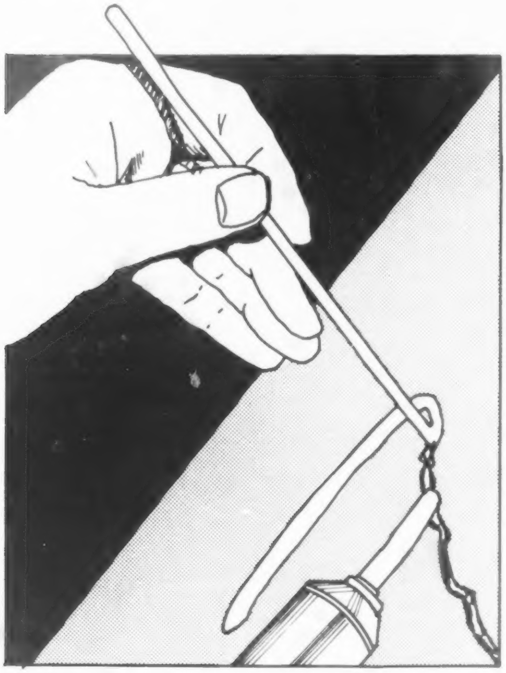
1. Remove tack-welding tip, and fit welder with round, hand-welding tip
2. Use cutting pliers to cut selected welding rod tip at a 60-degree angle to ensure good initial contact
3. Heat both welding rod and broken plastic until tacky
4. Push rod into base material at a 90-degree angle and keep firm, downward pressure on rod as it begins to move forward (Figure 10)

FIGURE 10



5. Use gentle fanning motion of welding tip to distribute heat evenly between rod and work surface (Figure 11)

FIGURE 11



6. Watch formation of weld bead and regulate your speed by the appearance of juicing

   (NOTE: Too little juicing indicates too much speed and is the signal to slow down.)

7. Hold rod briefly at end of weld and then cut with knife or clippers

O. Disconnect welder from power source

P. Trim and/or sand weld as required

Q. Refinish as required

R. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #6 — HOT-AIR WELD A LONG, STRAIGHT CRACK

I. Equipment and materials

- A. Hot-air weld
- B. Tack-welding tip and round speed-welding tip
- C. Color-coded welding rods
- D. Matches
- E. Hand rotary grinder or small rotary file and medium-grit abrasive
- F. Knife or clippers
- G. Wax and grease remover
- H. Clean cloth
- I. Soft wire brush
- J. Particle mask
- K. Rubber gloves
- L. Cutting pliers
- M. Masking tape
- N. Eye protection

II. Procedure

- A. Use national identification symbol or burn test to determine class and type of damaged plastic
- B. Use color coding or melt test to select proper welding rod
- C. Mask off area adjacent to damage as necessary
- D. Put on eye protection and rubber gloves
- E. Read instructions and cautions on wax and grease remover

JOB SHEET #6

F. Wipe repair area clean with wax and grease remover, following manufacturer's application instructions

CAUTION

Avoid inhaling the fumes from the wax and grease remover, or from any of the products used to bond plastic.

G. Remove rubber gloves, put on particle mask, and use hand rotary grinder or small rotary file to bevel edges of crack

(NOTE: Beveling provides a clean surface for the weld and increases the surface area for adhesion of the welding rod. Beveling may be made on the front or on the front and back of the weld. Front beveling [single V] is used for relatively thin material or when access to the reverse side is limited. Front and back beveling [double V] is used with thicker materials and requires less filling.)

H. Clean crack of all dust; surface must be absolutely clean for welding

I. Remove particle mask

J. Fit welder with tack-welding tip

K. Connect welder to power source and select correct temperature and pressure for type of plastic to be welded

L. Align cracked edges of panel; hold together while pressing hot welder tip against plastic

M. Tack-weld along entire length of damage to fuse edges in correct position

(NOTE: All weldable plastics, except polyurethane, can be tack-welded in this manner. Polyurethane is usually better aligned with tape or bonding adhesive.)

N. Weld damaged area

1. Remove tack-welding tip and fit welder with round, speed-welding tip
2. Use cutting pliers to cut selected welding rod tip at a 60-degree angle to ensure good initial contact
3. Insert welding rod in tube of high-speed welding tip
4. Heat both welding rod and broken plastic until tacky

JOB SHEET #6

5. Holding welding unit so that rod is at a 90-degree angle to work, press end of rod into weld with curved end of high-speed tip

6. Exert firm downward pressure and feed welding rod manually into feeder tube until welding bead begins to feed automatically

7. Move welder forward along weld, dropping angle of welder immediately to 45 degrees

8. Keep high-speed tip moving and watch formation of weld bead, adjusting heat or speed as needed

   (NOTE: Too little juicing indicates too much speed and is the signal to slow down.)

9. To stop high-speed weld before rod is fully used, set end of weld with firm pressure and then draw welder off remaining rod

10. Cut weld bead with knife or clippers

CAUTION

Do not allow the welding rod to remain in the hot feeder. It will melt and clog the opening.

O. Disconnect welder from power source

P. Clean feeder foot with soft wire brush as soon as welding is finished

Q. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

JOB SHEET #7 — HOT-AIR WELD A REPLACEMENT PIECE FOR A BROKEN PLASTIC PART OR TORN BOLT HOLE

I. Equipment and materials

   A. Hot-air welder

   B. Tack-welding and round hand-welding tips

   C. Color coded welding rods

   D. Matches

   E. Hand rotary grinder or small rotary file and medium-grit abrasive

   F. Plastic cutters

   G. Wax and grease remover

   H. Clean cloth

   I. Cutting pliers

   J. Particle mask

   K. Rubber gloves

   L. Eye protection

   M. Masking tape

II. Procedure

   A. Use national identification symbol or burn test to determine class and type of damaged plastic

   B. Use color coding or melt test to select proper welding rod

   C. Mask off area adjacent to damage as necessary

   D. Use plastic cutters to cut a piece of scrap plastic to make a patch of the same kind of plastic as that damaged

   E. Check for proper fit of replacement piece by placing it in broken area

   F. Put on eye protection and rubber gloves

JOB SHEET #7

G. Read instructions and cautions on wax and grease remover label

H. Wipe replacement piece and repair area clean with wax and grease remover, following manufacturer's instructions

CAUTION

Avoid inhaling the fumes from the wax and grease remover, or from any of the products used to bond plastic.

I. Remove rubber gloves, put on particle mask, and use hand rotary grinder or small rotary file to bevel edges of replacement piece and broken area

(NOTE: Small cracks and patching may be beveled on only one side [single V] of the crack.)

J. Clean replacement piece and broken part of all dust; surface must be absolutely clean for welding

K. Remove particle mask

L. Fit welder with tack-welding tip

M. Connect welder to power source and select correct temperature and pressure for type of plastic to be welded

N. Align replacement piece with edge of broken panel; hold together while pressing hot welder tip against both edges in weld area

O. Tack-weld along entire length of damage to fuse edges in correct position

(NOTE: All weldable plastics, except polyurethane, can be tack-welded in this manner. Polyurethane is usually better aligned with tape of bonding adhesive.)

P. Weld replacement piece to broken part

1. Remove tack-welding tip, and fit welder with round, hand-welding tip
2. Use cutting pliers to cut selected welding rod tip at a 60-degree angle to ensure good initial contact
3. Heat both welding rod and broken plastic until tacky
4. Push rod into base material at a 90-degree angle and keep firm, downward pressure on rod as it begins to move forward
5. Use gentle fanning motion of welding tip to distribute heat evenly between rod and work surface

JOB SHEET #7

6. Watch formation of weld bead and regulate your speed by the appearance of juicing

   (NOTE: Too little juicing indicates too much speed and is the signal to slow down.)

7. Hold rod briefly at end of weld, and then cut with knife or clippers

P. Disconnect welder from power source

Q. Trim and/or sand weld

R. Refinish as required

S. Clean work area and return equipment and materials to proper storage

PLASTIC REPAIR
UNIT II

TEST

NAME ____ SCORE ________________

1. Match to their correct definitions terms associated with plastic repair. Write the correct numbers in the blanks.

   ______a. Capable of eating into or wearing away as by rusting or the action of chemicals

   ______b. Catalyst that speeds up curing time of adhesive

   ______c. Moist appearance along sides of a weld

   ______d. Substance or agent that speeds up or sometimes slows down a chemical reaction

   ______e. Process of joining two or more like molecules to form a more complex molecule of different physical properties

   ______f. Letting some light shine through; partially transparent

   ______g. Greatest lengthwise stress a given substance can bear without tearing apart

   ______h. Process of using electrically heated, hot-air torch to soften and fuse base plastic and welding rod plastic

   ______i. Lasting despite hard wear or frequent use

   1. Polymerization
   2. Catalyst
   3. Corrosive
   4. Hot-air welding
   5. Translucent
   6. Tensile strength
   7. Durable
   8. Accelerator
   9. Juicing

2. Distinguish between characteristics of thermoset and termoplastic plastics. Write "TS" in the blank before characteristics of thermoset plastic and "TP" in the blank before characteristics of thermoplastic plastic.

   ______a. Class of plastic polymerized into a molecular structure that cannot later be changed by either heat or chemicals; not weldable

   ______b. Class of plastic having a molecular structure capable of being changed by chemicals, heating, or cooling; weldable

TEST

3. Identify the following national identification symbols for plastics. Write the correct symbols in the blanks.

_____________a. Noryl

_____________b. Thermoplastic polyurethane

_____________c. Polyester (fiberglass)

_____________d. Lexan

_____________e. Ethylene propylene diene monomer

_____________f. Thermoset polyurethane

_____________g. ABS vinyl

_____________h. Acrylonitrile butadiene styrene

_____________i. Nylon

_____________j. Polypropylene

_____________k. Thermoplastic rubber

_____________l. Polyethylene

_____________m. Polyvinyl chloride (vinyl)

4. Identify the following weldable plastics given their burning characteristics. Write the correct names in the blanks.

Polypropylene
Polyethylene
ABS

Polyvinyl chloride (vinyl)
Polyurethane

_______________________________a. Chars and gives off grey smoke
Has its own distinguishing smell
Is self-extinguishing

_______________________________b. Melts, swells, and drips
Drippings may burn
Smells like burning wax
Continues to burn when flame is removed

_______________________________c. Burns with a yellow-orange flame and black smoke
Flame sputters
Continues to burn when flame is removed

_______________________________d. Burns with no visible smoke
Has its own distinguishing smell
Continues to burn when flame is removed

TEST

______________________e. Burns with a thick, black, sooty smoke that hangs in the air
Has its own distinguishing smell
Continues to burn when flame is removed

5. Match the five most common auto-body plastics to their principal applications. Write the correct numbers in the blanks.

______a. Grills; dash panels; rigid interior trim

______b. Holding tanks; trim panels

______c. Inner aprons; fan shrouds; splash panels; heater housing ducts; trim panels; rigid seat parts

______d. Vinyl sheeting in tops and seats; some bumper fillers and crash pads

1. Polypropylene
2. Polyethylene
3. Acrylonitrile butadiene styrene
4. Polyethylene
5. Polyvinyl chloride

6. List basic auto body plastic repair techniques.

a. ____

b. ____

c. ____

7. Match the following most commonly used auto body plastics to their correct repair procedures. Write the correct numbers in the blanks.

______a. Use heat to repair dents; hot-air weld tears or fills; bond with cement or fill with structural adhesive; sand smooth and paint

______b. Hot-air weld; sand welds for appearance; fill with paste of MEK (methyl ethyl ketone) and ABS plastic, or with structural adhesives

______c. Hot-air weld; trim and/or sand weld; refinish as required

______d. Hot-air weld; sand welds for appearance; paint or undercoat for uniform finish if desired

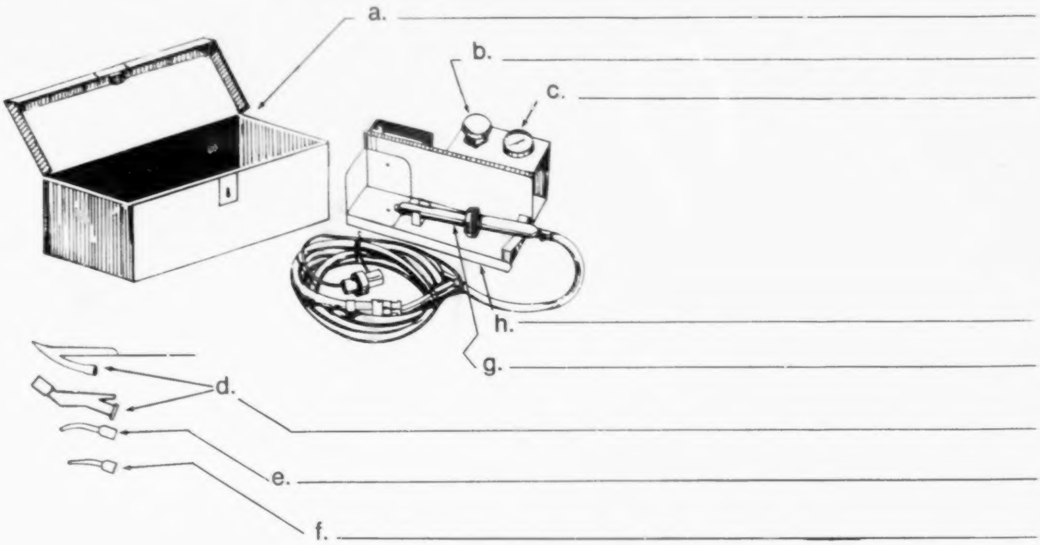
______e. Use heat to repair dents; bond with cement or fill with structural adhesive; reinforce with fiberglass mat on large tears; sand smooth and paint

______f. Use heat to repair dents; hot-air weld; sand welds for appearance; finish with flat black or undercoat on aprons, or with plastic paint on trim panels

1. Thermoset polyurethane
2. Termoplastic polyurethane
3. Polypropylene
4. Polyethylene
5. Acrylonitrile butadiene styrene
6. Polyvinyl chloride

TEST

8. Label the parts of the hot-air (plastic) welder illustrated below.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

9. Match hot-air welding tips to their correct uses. Write the correct numbers in the blanks.

_____a.	Used for general welding and for damaged parts that have hard-to-reach areas, tight, sharp corners, or small holes	1. Tack-welding tip 2. Round tip
_____b.	Used to align and temporarily hold in place a torn or split panel	3. High-speed tip
_____c.	Used for automatic feed-tip operation and fast, one-handed welding of long, straight surfaces	

10. List five guidelines for achieving quality hot-air welds.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

TEST

11. Match welding rod color codes to the plastic for which each is intended. Write the correct numbers in the blanks.

    ______a. Polyurethane

    ______b. Polypropylene

    ______c. ABS

    ______d. Polyvinyl chloride

    ______e. Polyethylene

    1. Light grey
    2. Brown
    3. Yellow/clear
    4. Blue
    5. Black

(NOTE: Test item 12 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

12. Demonstrate the ability to

    a. Perform burn tests and melt tests identify plastics.

    b. Adhesive bond a minor tear or crack.

    c. Chemically bond a puncture.

    d. Chemically bond an outer-edge tear.

    e. Hot-air weld a minor tear or crack.

    f. Hot-air weld a long, straight crack.

    g. Hot-air weld a replacement piece for a broken plastic part or torn bolt hole.

PLASTIC REPAIR
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 8
   c. 9
   d. 2
   e. 1
   f. 5
   g. 6
   h. 4
   i. 7

2. a. TS
   b. TP

3. a. PPO
   b. TPUR
   c. UP
   d. PC
   e. EPDM
   f. PUR
   g. ABS/PVS
   h. ABS
   i. PA
   j. PP
   k. TPR
   l. PE
   m. PVC

4. a. Polyvinyl chloride
   b. Polyethylene
   c. Polyurethane
   d. Polypropylene
   e. ABS

5. a. 3
   b. 2
   c. 1
   d. 5
   e. 4

6. a. Adhesive bonding (cement)
   b. Chemical bonding (structural adhesive)
   c. Hot-air welding

7. a. 2
   b. 5
   c. 6
   d. 4
   e. 1
   f. 3

ANSWERS TO TEST

8. a. Carrying case
   b. Air regulator
   c. Pressure gauge
   d. High-speed tips (round and ribbon)
   e. Round tip
   f. Tack-welding tip
   g. Heating element
   h. Welder stand

9. a. 2
   b. 1
   c. 3

10. Answer should include any five of the following

    a. Use recommended pressure for plastic being welded
    b. Select correct temperature for plastic being welded
    c. Choose a rod length that matches that of the weld; never stretch rod over weld
    d. Hold both tip and rod at correct angle
    e. Keep downward pressure on rod at all times to achieve a good bond
    f. Apply at a steady speed that allows juicing to occur along each side of weld

11. a. 3
    b. 5
    c. 4
    d. 1
    e. 2

12. Performance skills evaluated to the satisfaction of the instructor

INTERIOR TRIM
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to identify, remove, and replace vehicle seats and other interior trim. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Label typical interior hardware and trim.
2. Match to their correct definitions terms associated with interior trim.
3. List mounting methods for interior handles.
4. Select from a list methods of fastening headliners.
5. Identify types of attachments used to fasten trim panels.
6. Demonstrate the ability to
    a. Remove and reinstall a clip-attached handle.
    b. Remove and reinstall a screw-attached handle.
    c. Remove and reinstall a door trim panel.
    d. Remove and reinstall front and rear seats.
    e. Drop and reinstall a headliner.

INTERIOR TRIM
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Job sheets

      1. Job Sheet #1 — Remove and Reinstall a Clip-Attached Handle

      2. Job Sheet #2 — Remove and Reinstall a Screw-Attached Handle

      3. Job Sheet #3 — Remove and Reinstall a Door Trim Panel

      4. Job Sheet #4 — Remove and Reinstall Front and Rear Seats

      5. Job Sheet #5 — Drop and Reinstall a Headliner

   E. Test

   F. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials needed to supplement unit.

      1. Equipment and materials for job sheet procedures

      2. Examples of different clip attachments and headliner installations

      3. Competency profiles

         (NOTE: Competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

   C. Provide students with unit.

   D. Introduce unit.

   SUGGESTIONS:

   - Discuss the importance of being able to recognize various pieces of interior trim and their methods of attachment.

   - Discuss unit and specific objectives. Explain that accomplishment of the specific objectives leads to attainment of the unit objective.

SUGGESTED ACTIVITIES

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to typical interior hardware and trim.

   SUGGESTIONS:

   - Have students identify typical interior hardware and trim on many makes and models of vehicles.
   - Discuss the evolution of interior hardware and trim over the past several years.

     EXAMPLES: Elimination of ventilator windows and regulator handles, armrests molded to door panel trim, mandatory headrests, mandatory chest and lap seatbelts, molded vinyl headliners, electric window controls, recessed snap-open door handles, removable parcel shelves, etc.

   - Have students compare interior hardware on different makes and models of vehicles.

2. Use Information Sheet, Section II to introduce students to terms and definitions associated with interior trim.

   SUGGESTION:

   - Show students examples when appropriate.

3. Use Information Sheet, Sections III through V to discuss methods of mounting interior handles, fastening headliners, and fastening trim panels.

   SUGGESTIONS:

   - Show students different mounting and fastening methods on different makes and models.
   - Demonstrate and discuss procedures outlined in Job Sheets #1 through #5.
   - Have students complete Job Sheets #1 through #5.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest if necessary.

I. Complete appropriate section of competency profiles.

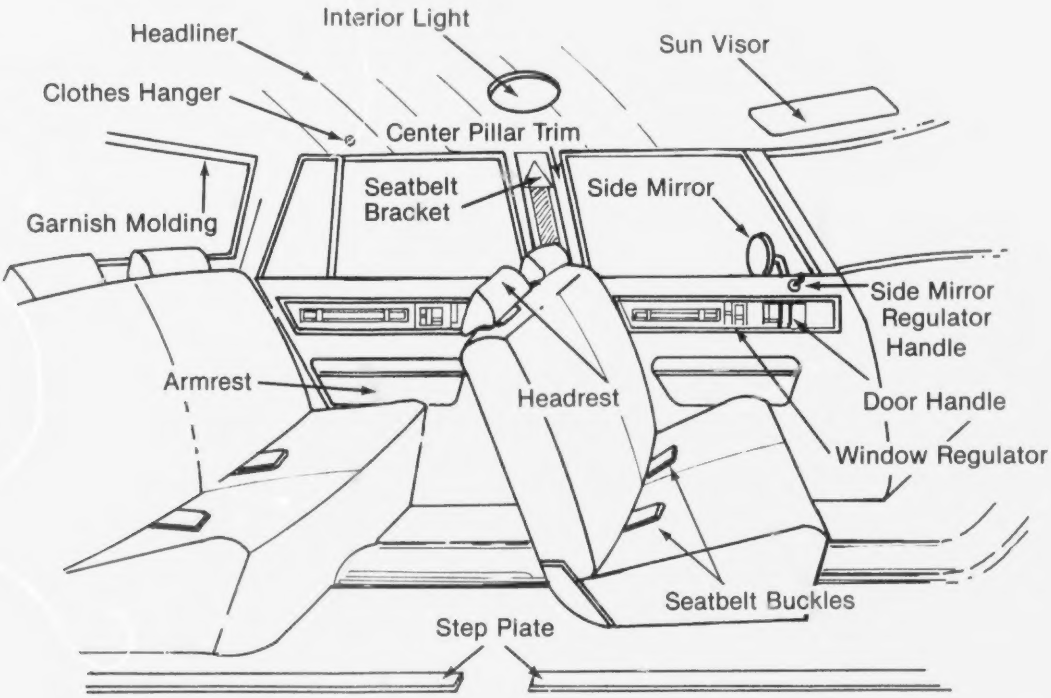
III. Unit reference — Manuel, Edward F. *Auto Body*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1974.

INTERIOR TRIM
UNIT I

INFORMATION SHEET

I. Typical interior hardware and trim (Figure 1)

FIGURE 1



II. Terms and definitions

A. Armrest — That part of door trim panel upon which arm of driver or passenger may rest

B. Cushion — Bottom part of front or rear seat

C. Backrest — Back part of front or rear seat

D. Headrest — Top extension of front or rear seat backrest, may be fixed or movable

E. Kick pad — Part of vehicle interior that fits between front door opening and cowl on both left and right sides under dash panel

F. Step plate — Panel that covers edge of floor mat in door opening

INFORMATION SHEET

G. Garnish molding — Any interior trim molding that fits around windshield, rear window, or door glass

H. Clothes hanger — Hooklike piece of trim molding fastened to inside roof rail

I. Trim panel — Vinyl or cloth trim used to cover an interior panel

J. Floor mat — Carpet or rubber floor covering

K. Parcel shelf — Ledge behind rear seat backrest at rear window

L. Weatherstrip — Material used to seal the crack between doors and door openings

M. Center pillar trim — Trim used to cover post between front and rear doors or windows

N. Sun visor — Covered panel above windshield that can be lowered to protect passenger's eyes from sunlight

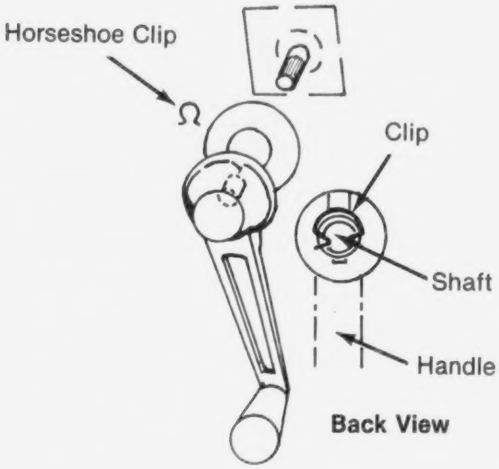
O. Headliner — Cloth, vinyl, or interior board that covers interior roof to protect passengers from undercoating and to act as a sound deadener

III. Mounting methods for interior handles (Figures 2 and 3)

A. Clip-attached

EXAMPLE:

FIGURE 2

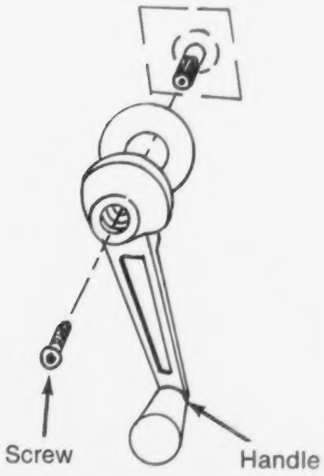


INFORMATION SHEET

B. Screw-attached

EXAMPLE:

FIGURE 3



IV. Methods of fastening headliners

A. To side roof rail with listing wire

B. Between pronged retainer and roof rail

C. Behind headliner with tension strips

(NOTE: This method is used on foreign vehicles.)

D. With tack strips covered by moldings and trim strips

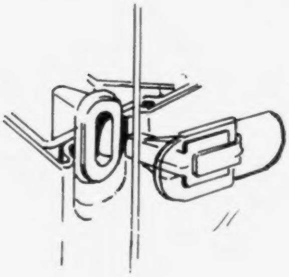
V. Common attachments used to fasten trim panels (See Figures 4-7)

(NOTE: Clips come in a wide variety of sizes and designs. Replacement clips should be of the same size and design as those removed.)

INFORMATION SHEET

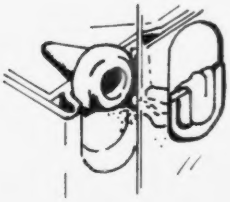
A. Oblong clip

FIGURE 4



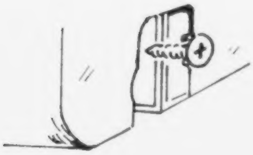
B. Round clip

FIGURE 5



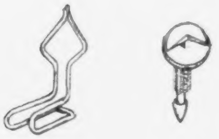
C. Screw

FIGURE 6



D. Plastic clip

FIGURE 7



INTERIOR TRIM
UNIT I

JOB SHEET #1 — REMOVE AND REINSTALL A CLIP-ATTACHED HANDLE

I. Equipment and materials

   A. Door-handle pliers

   B. Door-handle clip removal tool

   C. Upholstery covers

   D. Eye protection

   E. Service manual for vehicle being worked on

II. Procedure

   (NOTE: When working on interior trim, always keep your hands clean, keep tools on floorboards and off seats, and do not put tools in your pockets because you may tear the seats or other parts of the interior when sitting in the vehicle.)

   A. Put on eye protection

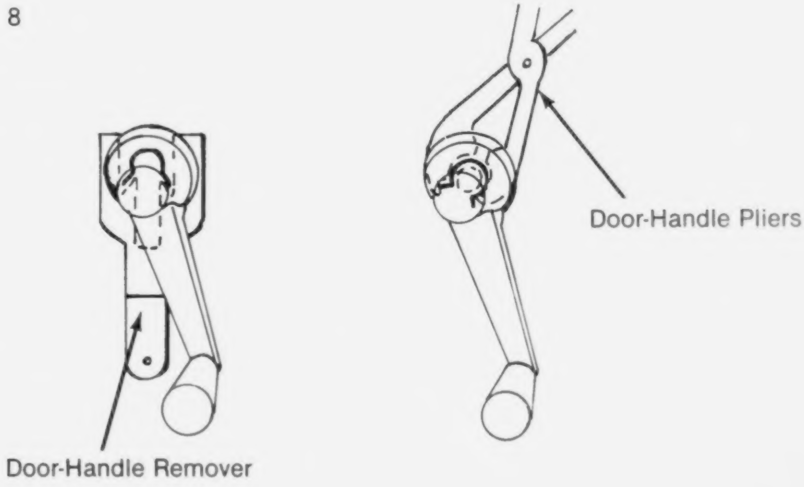
   B. Protect vehicle upholstery with upholstery cover

   C. Use pliers or handle remover to remove clip as shown in Figure 8

CAUTION

Take care not to insert tool between escutcheon plate and trim panel. If the tool comes in contact with the cloth or vinyl trim panel, the panel could be torn and damaged.

FIGURE 8



JOB SHEET #1

D. Remove handle, using appropriate tools

E. Reinstall clip on repaired or replacement handle

(NOTE: If clip was bent or damaged during removal, you may have to install a new clip.)

F. Reinstall handle

1. Place escutcheon plate over regulator or remote-control shaft
2. Push handle onto shaft, aligning with like handle on opposite door and working handle several times to be sure that it is properly seated

G. Remove protective covers from vehicle

H. Clean work area and return equipment and materials to proper storage

INTERIOR TRIM
UNIT I

JOB SHEET #2 — REMOVE AND REINSTALL A SCREW-ATTACHED HANDLE

I. Equipment and materials

  A. Hex wrench set

  B. Phillips or Torx screwdriver

  C. Upholstery covers

  D. Eye protection

  E. Service manual for vehicle being worked on

II. Procedure

(NOTE: When working on interior trim, always keep your hands clean, keep tools on floorboards and off seats, and do not put tools in your pockets because you may tear the seats or other parts of the interior when sitting in the vehicle.)

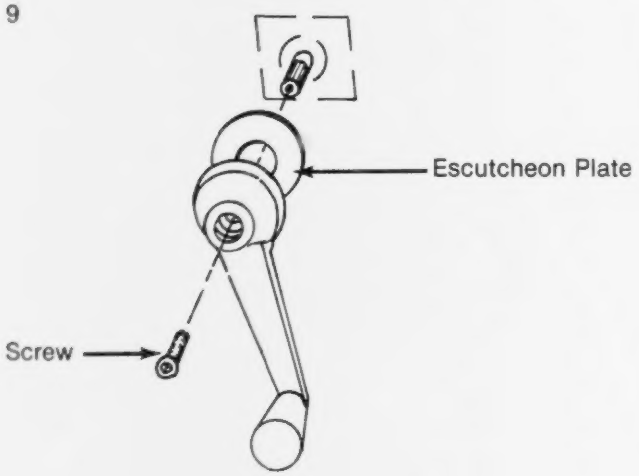
  A. Put on eye protection

  B. Protect vehicle upholstery with upholstery cover

  C. Note position of handle in relationship to like handle on opposite door

  D. Use appropriate tool to remove screw from handle; set screw aside where it will not get lost (Figure 9)

FIGURE 9



JOB SHEET #2

E. Remove handle

F. Remove escutcheon plate

G. Reinstall escutcheon plate

(NOTE: If escutcheon plate, handle, or screw is damaged, it will need to be replaced. Check the service manual for proper replacement parts.)

H. Reinstall handle, aligning it with like handle on opposite door

I. Reinstall screw

J. Remove protective covers from vehicle

K. Clean work area and return equipment and materials to proper storage

INTERIOR TRIM
UNIT I

JOB SHEET #3 — REMOVE AND REINSTALL A DOOR TRIM PANEL

I. Introduction

  A. When working on interior trim, always keep your hands clean, keep tools on floorboards and off seats, and do not put tools in your pockets because you may tear the seats or other parts of the interior when sitting in the vehicle

  B. Remove the dust cover/watershield carefully; these covers must be replaced intact to prevent dust from getting into the interior of the vehicle

  C. Be sure to use the proper tools for the job, and do not use excessive pressure

  D. Examine all clips to determine whether they are reusable; reuse clips when possible and replace clips when necessary

II. Procedure

  A. Put on eye protection

  B. Cover vehicle upholstery with upholstery cover

  C. Because door trim panel installation varies for different makes and models of vehicles, refer to manufacturer's service manual for specific make and model on which you are working

  D. Clean work area and return tools and equipment to proper storage when the job is complete

INTERIOR TRIM
UNIT I

JOB SHEET #4 — REMOVE AND REINSTALL FRONT AND REAR SEATS

I. Introduction

A. When working on interior trim, always keep your hands clean, keep tools on floorboards and off seats, and do not put tools in your pockets because you may tear the seats or other parts of the interior when sitting in the vehicle

B. If vehicle must be jacked up to gain access to bolts, be sure to use safety stands

C. Avoid back injury; always have someone help you lift the seat out of the vehicle; do not chance injury to yourself or damage to floor mats, door panel, or paint

II. Procedure

A. Put on eye protection

C. Because seats are installed in various ways for different makes and models of vehicles, refer to manufacturer's service manual for specific make and model on which you are working

D. Clean work area and return tools and equipment to proper storage when the job is complete

INTERIOR TRIM
UNIT I

JOB SHEET #5 — DROP AND REINSTALL A HEADLINER

I. Introduction

A. Cover all interior—seats, dash, parcel shelf, etc.—and keep hands and all tools clean to prevent soiling headliner, upholstery, or other interior fabrics

B. Interior surfaces must be covered also because fiberglass insulation may have been used as a sound deadener; fiberglass particles will embed in the seats and other trim areas, creating an irritating and dirty condition that is almost impossible to clean up

C. Use the correct tools for the job, and do not apply too much pressure

D. It is very important to double-check to see that *all* fasteners have been removed; the headliner can be torn if they are not all removed before dropping

E. The headliner must fit all areas *exactly* as did the original installation so that molding and trim can be reinstalled and not leave obvious marks indicating that the headliner was moved

II. Procedure

A. Cover all interior surfaces of vehicle—seats, dash, parcel shelf, etc.

B. Put on eye protection

C. Remove all interior hardware and trim that would interfere with headliner removal

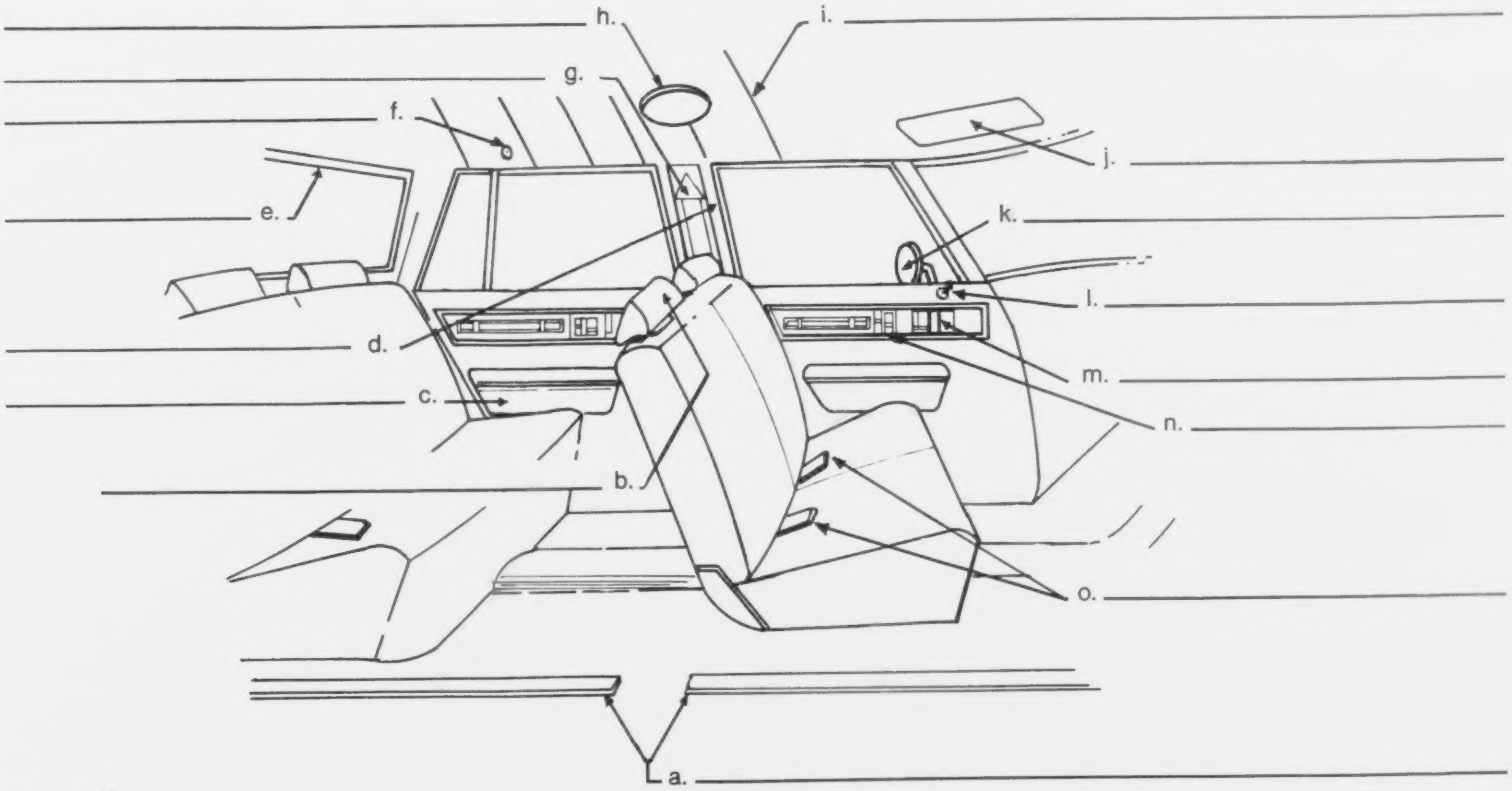
D. Because headliners are installed in various ways for different makes and models of vehicles, refer to manufacturer's service manual for specific make and model on which you are working

(NOTE: Headliners on today's vehicles are made of a variety of substances and are installed in a number of different ways. To prevent damage to the headliner, always check vehicle service manual for specific removal methods.)

INTERIOR TRIM
UNIT I
TEST

NAME ______________________ SCORE ______________

1. Label typical interior hardware and trim illustrated below.



TEST

2. Match to their correct definitions terms associated with interior trim. Write the correct numbers in the blanks.

______ a. Trim used to cover post between front and rear doors or windows

______ b. Bottom part of front or rear seat

______ c. Back part of front or rear seat

______ d. Any interior trim molding that fits around windshield, rear window, or door glass

______ e. Part of vehicle interior that fits between front door opening and cowl on both left and right sides under dash panel

______ f. Cloth, vinyl, or interior board that covers interior roof to protect passengers from undercoating and to act as a sound deadener

______ g. Carpet or rubber floor covering

______ h. Ledge behind rear seat backrest at rear window

______ i. That part of door trim panel upon which arm of driver or passenger may rest

______ j. Covered panel above windshield that can be lowered to protect passenger's eyes from sunlight

______ k. Hooklike piece of trim molding fastened to inside roof rail

______ l. Panel that covers edge of floor mat in door opening

______ m. Vinyl or cloth trim used to cover an interior panel

______ n. Top extension of front or rear seat backrest; may be fixed or movable

______ o. Material used to seal the crack between doors and door openings

1. Armrest
2. Cushion
3. Backrest
4. Headrest
5. Kick pad
6. Step plate
7. Garnish molding
8. Clothes hanger
9. Trim panel
10. Floor mat
11. Parcel shelf
12. Weatherstrip
13. Center pillar trim
14. Sun visor
15. Headliner

3. List mounting methods for interior handles.

a. ____

b. ____

TEST

4. Select from the following list methods of fastening headliners. Write an "X" in the blank before each correct answer.

   ______a. To drip rail with listing wire

   ______b. Between pronged retainer and roof rail

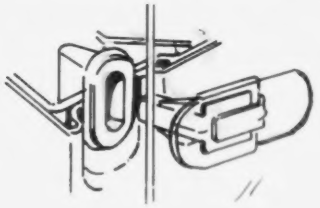
   ______c. Behind headliner with screws or bolts

   ______d. With tack strips covered by moldings and trim strips

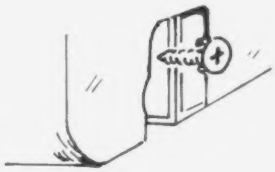
   ______e. To side roof rail with listing wire

   ______f. Behind headliner with tension strips

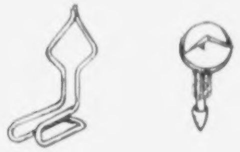
5. Label the following types of attachments used to fasten trim panels.



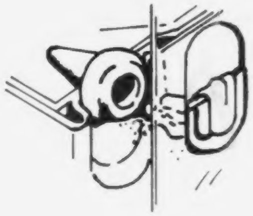
a. ________________________________



b. ________________________________



c. ________________________________



d. ________________________________

(NOTE: Test item 6 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

6. Demonstrate the ability to

   a. Remove and reinstall a clip-attached handle.

   b. Remove and reinstall a screw-attached handle.

   c. Remove and reinstall a door trim panel.

   d. Remove and reinstall front and rear seats.

   e. Drop and reinstall a headliner.

INTERIOR TRIM
UNIT I

ANSWERS TO TEST

1. a. Step plate
   b. Headrest
   c. Armrest
   d. Center pillar trim
   e. Garnish molding
   f. Clothes hanger
   g. Seatbelt bracket
   h. Interior light
   i. Headliner
   j. Sun visor
   k. Side mirror
   l. Side mirror regulator handle
   m. Door handle
   n. Window regulator
   o. Seatbelt buckles

2. a. 13
   b. 2
   c. 3
   d. 7
   e. 5
   f. 15
   g. 10
   h. 11
   i. 1
   j. 14
   k. 8
   l. 6
   m. 9
   n. 4
   o. 12

3. a. Clip-attached
   b. Screw-attached

4. b, d, e, f

5. a. Oblong clip
   b. Screw
   c. Plastic clip
   d. Round clip

6. Performance skills evaluated to the satisfaction of the instructor

DOOR GLASS AND HARDWARE
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to identify, remove, and reinstall various door glass and hardware. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with door glass and hardware.
2. Distinguish between laminated safety plate glass and solid tempered plate glass.
3. Label typical interior door glass components and hardware.
4. List ways in which door glass is held to the door regulator.
5. Identify typical door glass hardware.
6. Name types of window regulators.
7. Select from a list common repairs needed on door glass and hardware.
8. Demonstrate the ability to
    a. Remove and replace weatherstripping on a door.
    b. Remove and replace door glass.
    c. Remove and replace a window regulator.
    d. Remove and replace a door latch assembly.

DOOR GLASS AND HARDWARE
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

  A. Objective sheet

  B. Suggested activities

  C. Transparency masters

    1. TM #1 — Arm-Type Window Regulator and Door Hardware

    2. TM #2 — Strap-Type Window Regulator and Door Hardware

    3. TM #3 — Plastic Strap-Type Window Regulator and Door Hardware

    4. TM #4 — Vent Glass Hardware

  D. Information sheet

  E. Job sheets

    1. Job Sheet #1 — Remove and Replace Weatherstripping on a Door

    2. Job Sheet #2 — Remove and Replace Door Glass

    3. Job Sheet #3 — Remove and Replace a Window Regulator

    4. Job Sheet #4 — Remove and Replace a Door Latch Assembly

  F. Test

  G. Answers to test

II. Instructor's guide

  A. Review unit and plan presentation.

  B. Order or obtain materials needed to teach unit.

    1. Equipment and materials for job sheet performance

    2. Various types of door glass and hardware for demonstration purposes

    3. Transparencies and competency profiles

    (NOTE: Transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

  C. Provide students with unit.

SUGGESTED ACTIVITIES

D. Introduce unit.

SUGGESTIONS:

- Explain the need for technicians trained in removing, replacing, and adjusting door glass and hardware.
- Explain that accomplishment of the specific objectives enables the students to attain the unit objective.

E. Discuss and demonstrate information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with door glass and hardware.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss the differences between laminated safety plate glass and solid tempered plate glass.

   SUGGESTIONS:

   - Explain the advantages of these types of glass over ordinary plate glass.
   - Demonstrate to students what happens when solvents come in contact with the plastic layer in the laminated glass.
   - Demonstrate how each of these types of glass breaks. Hit pieces of scrap glass with a hammer for demonstration purposes, or make a display board showing previously broken laminated and tempered plate glass.

3. Use Information Sheet, Section III to introduce students to typical interior door components and hardware.

   SUGGESTION:

   - Show students actual examples on various makes and models of vehicles.

4. Use Information Sheet, Section IV to explain ways in which door glass is held to the door regulator.

   SUGGESTION:

   - Show students examples of the different fastening methods.

5. Use Information Sheet, Sections V and VI to introduce students to typical door glass hardware and window regulators.

   SUGGESTIONS:

   - Use Transparencies #1 through #4 to illustrate your discussion.

SUGGESTED ACTIVITIES

- Show students examples of hardware and regulators on various makes and models of vehicles.
- Caution students about the hazards of spring-loaded regulators.

6. Use Information Sheet, Section VII to discuss common repairs needed on door glass and hardware.

SUGGESTIONS:

- Discuss and demonstrate each of the job sheets.
- Allow students to complete Job Sheets #1 through #4. Have students who grasp the skills quickly work with those who need remediation.

F. Give test.

G. Critique test and discuss in class.

H. Complete appropriate section of competency profiles.

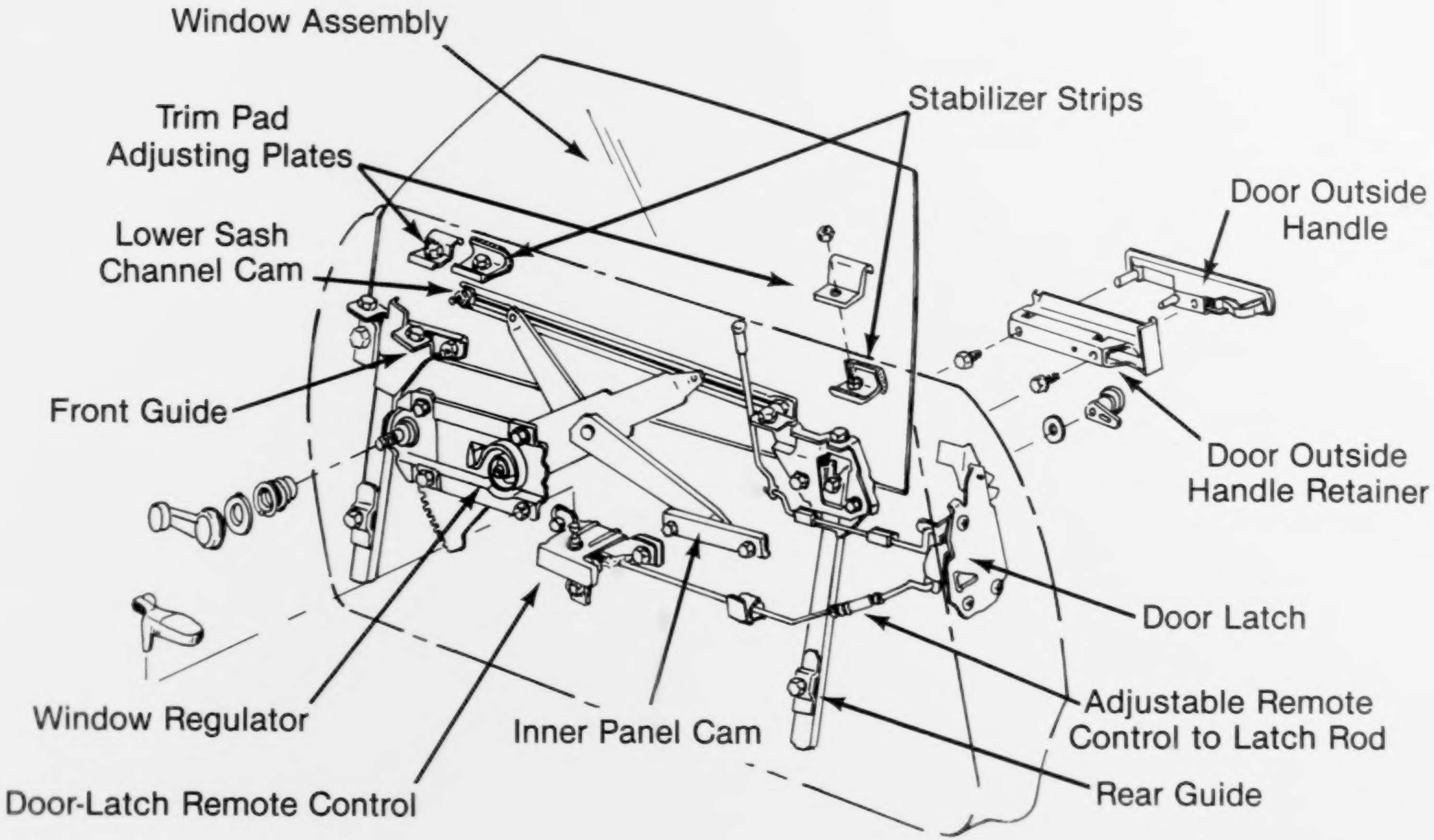
III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: Gregg Division of McGraw-Hill Book Company, 1986.

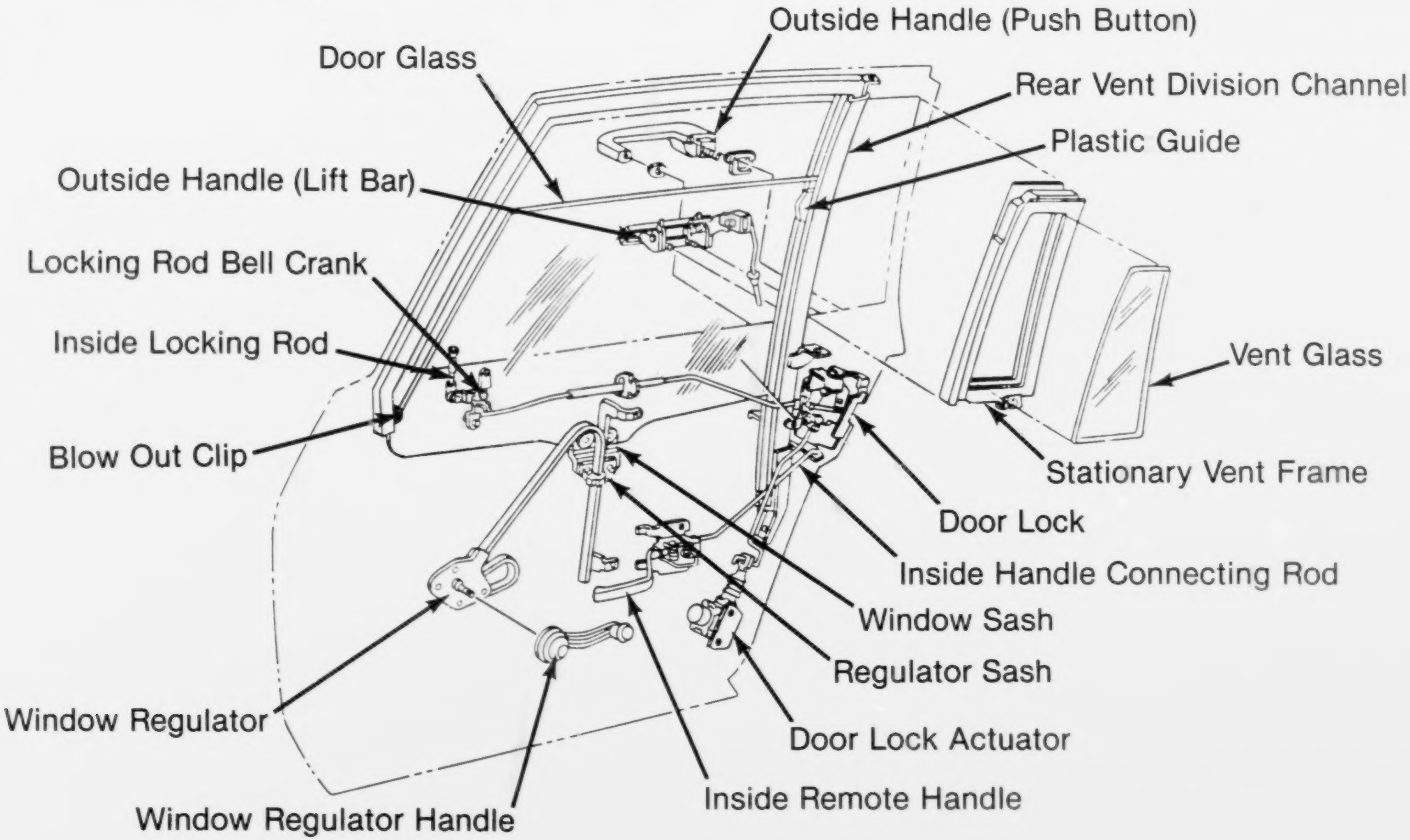
B. Rhone, L.C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

C. Manual, Eduard F. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1974.

Arm-Type Window Regulator and Door Hardware



Strap-Type Window Regulator and Door Hardware



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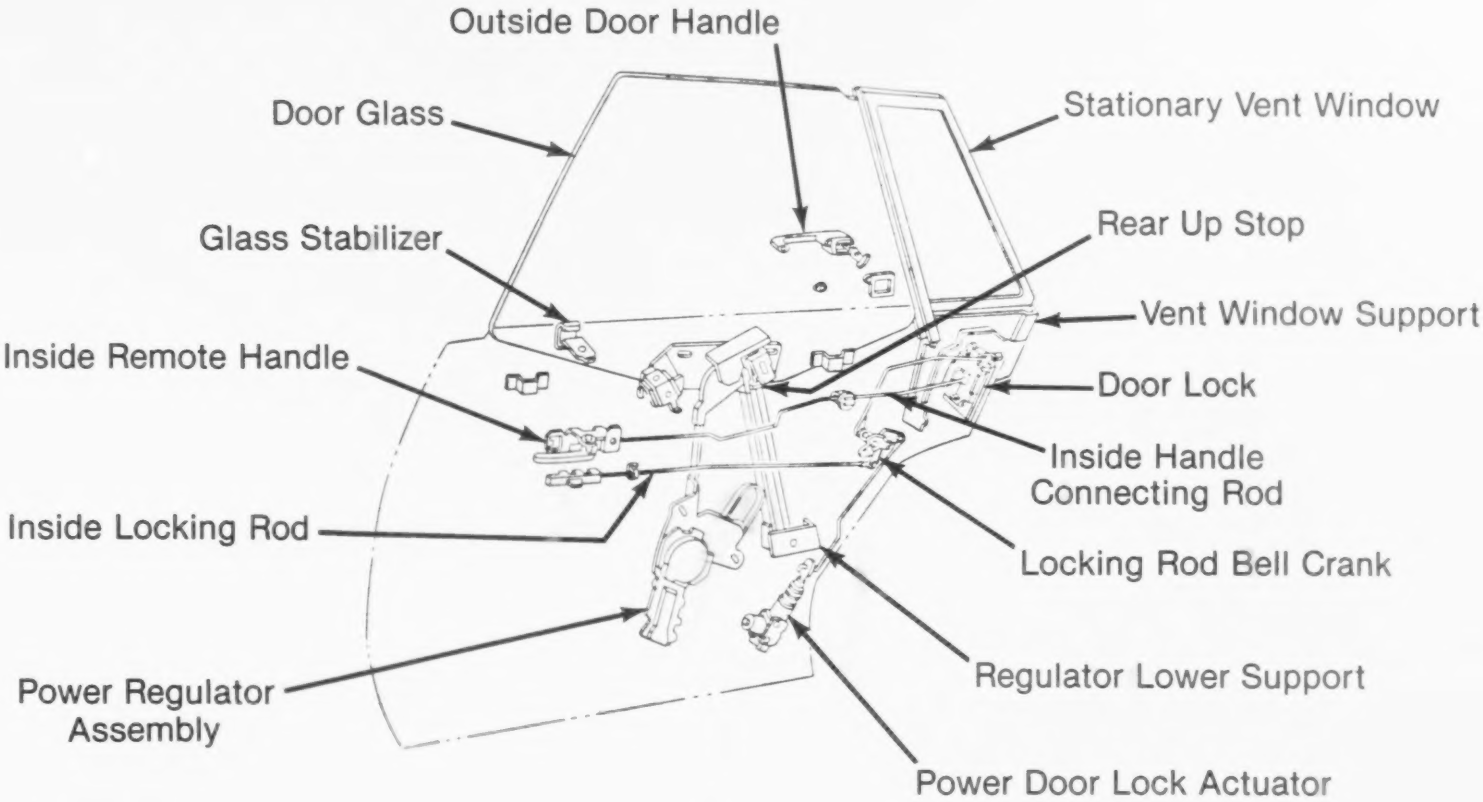
Plastic Strap-Type Window Regulator and Door Hardware



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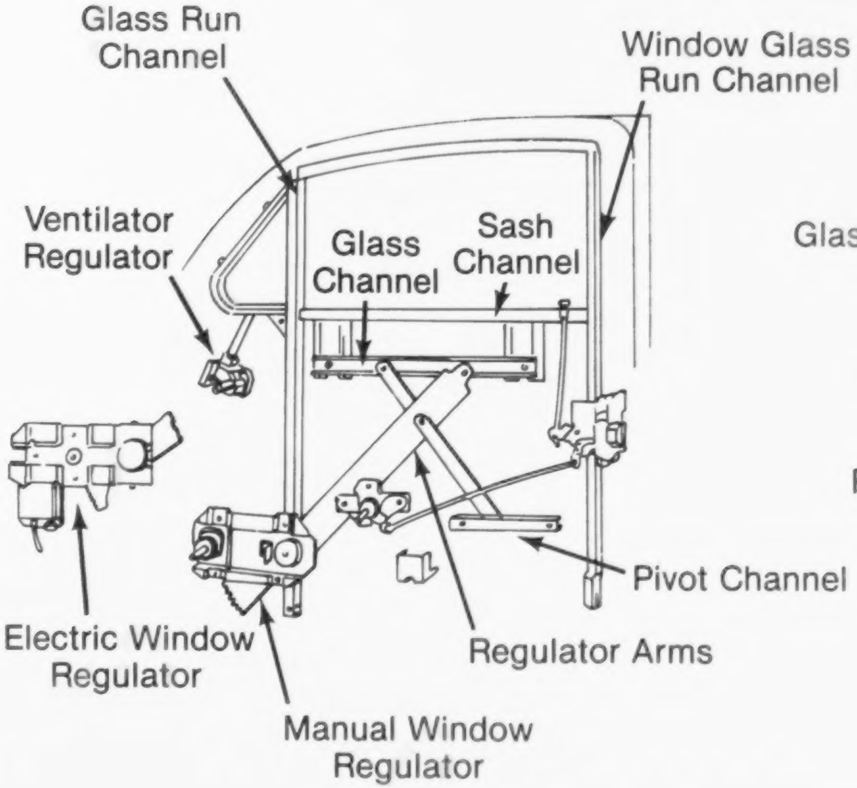
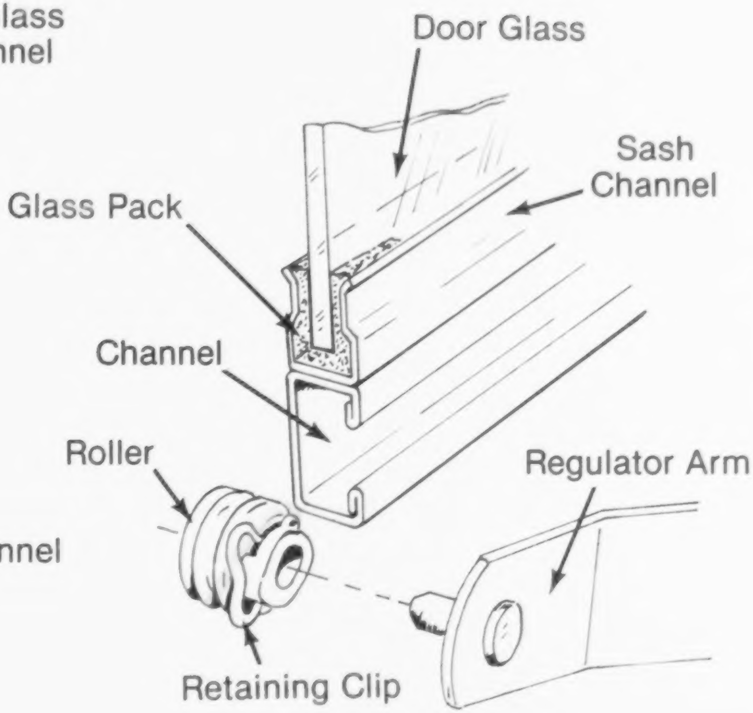
Vent Glass Hardware





DOOR GLASS AND HARDWARE
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Glass hardware — All parts in vehicle body needed to hold or move glass

      (NOTE: The largest pieces of glass hardware are regulator assemblies, the mechanisms that move the glass up or down.)

   B. Movable glass — Glass used in vehicle windows that can be opened

   C. Ventilator (vent) window — Small wing glass that opens and shuts in an in-and-out rather than an up-and-down movement

   D. Regulator — Gear-operated mechanism that lowers or raises glass; may be manual or power operated

   E. Remote control — Electronic device used to raise or lower windows or open or lock latches from driver's seat

   F. Cam — Roller or slide block that runs in channel or guide and allows glass to be raised or lowered

   G. Stabilizer strip — Cushioned strip used to stabilize window to prevent rattling when window is lowered

   H. Glass run channel — Groove in which glass slides between top and side of door

   I. Center-division channel — Groove between door glass and vent glass in doors with vent windows

   J. Sash channel — Grove used to fasten door glass to regulator

   K. Guides — Parts that control or direct the up-and-down motion of glass; used in place of center-division channel or run channel

   L. Frameless glass — Movable glass held in place by bolts through a channel rather than by a surrounding metal frame

   M. Equalizer arm — Pivot channel that allows for adjustment of glass

      (NOTE: The pivot channel may be adjustable or fixed. If the channel is fixed, then the regulator must be adjustable.)

   N. Stop — Rubber piece used to prevent glass from rolling out the top or off the bottom guides

INFORMATION SHEET

II. Descriptions of types of glass used in vehicles

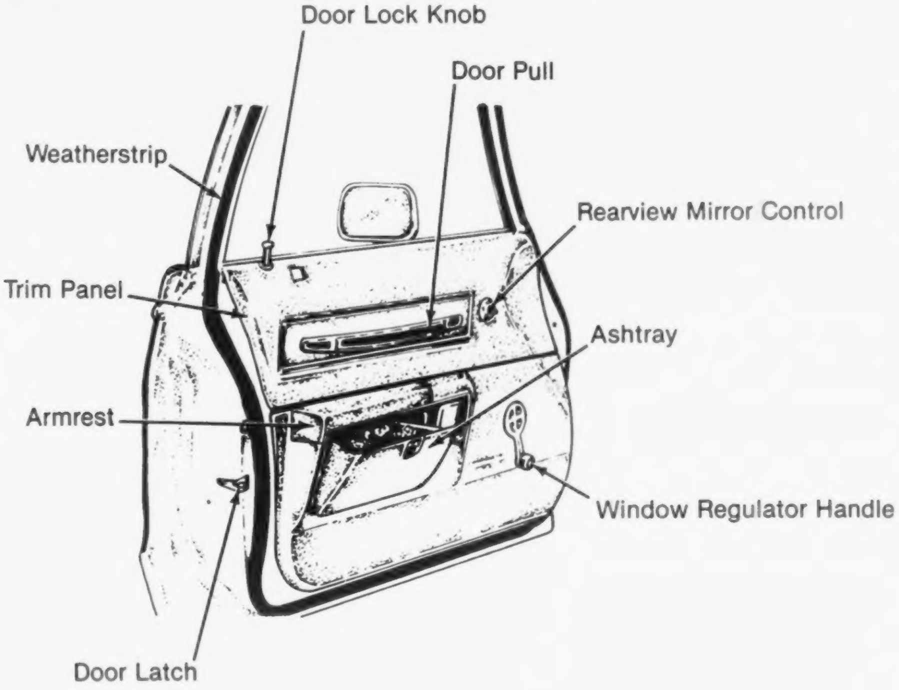
   A. Laminated safety plate glass — Layer of plastic material sandwiched between two layers of glass; plastic reduces possibility of glass shattering and prevents broken pieces from flying off if glass does break; used in all windshields

   (NOTE: When cleaning laminated glass, do not allow any solvent to get onto the edges of the glass and touch the plastic center layer. The plastic will absorb the solvent and cause the glass to discolor.)

   B. Solid tempered plate glass — Treated to be less brittle than ordinary plate glass; when broken, tends to crumble into very small pieces with no sharp edges; used in side and back windows

III. Typical interior door components and hardware (Figure 1)

FIGURE 1



IV. Ways in which door glass is held to door regulator

   A. Cam rollers and retaining clips

   B. Shoulder-type retaining bolts with plastic bushings for frameless glass

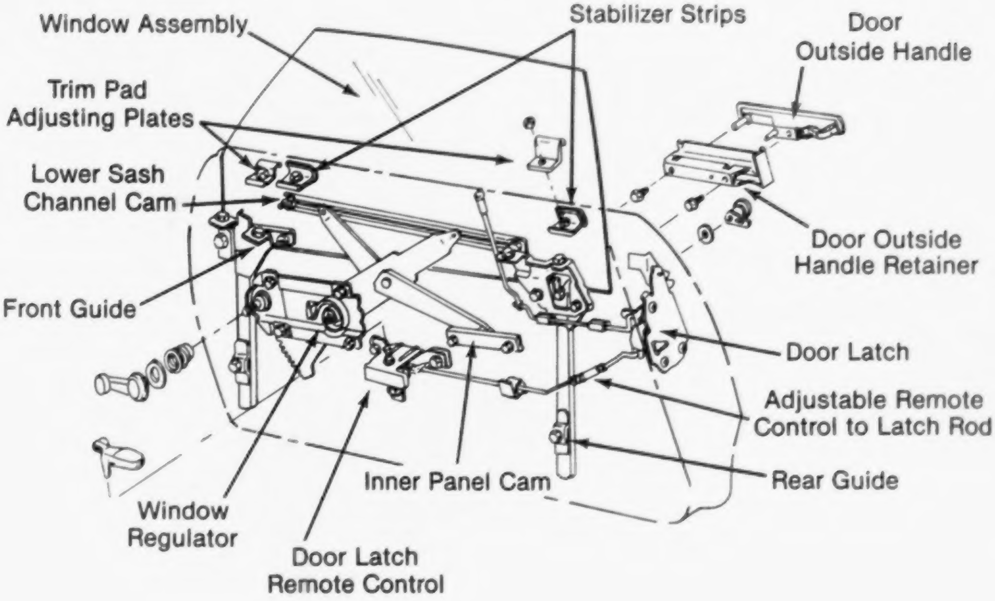
   C. Sash channel bonded to glass with urethane or structural adhesive

   (NOTE: This method of attachment is less common today than the other two methods.)

INFORMATION SHEET

V. Typical door glass hardware (Figure 2)

FIGURE 2

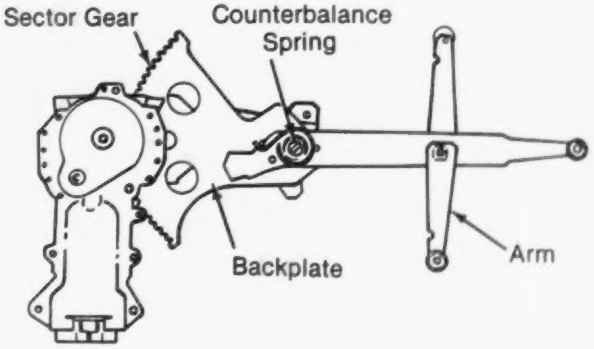


VI. Types of window regulators (Figures 3 and 4)

A. Arm type

EXAMPLE:

FIGURE 3

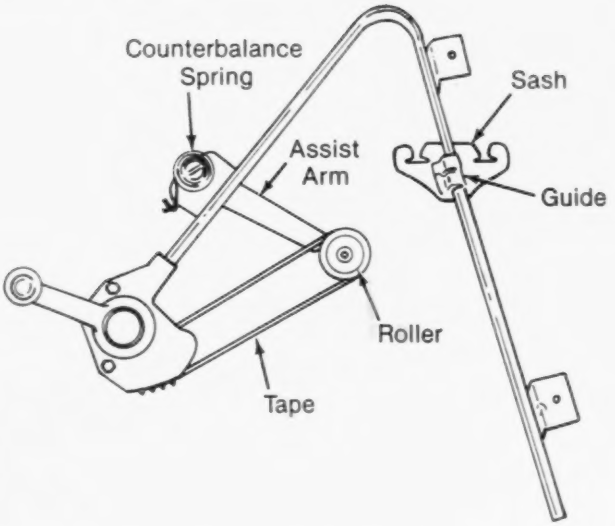


INFORMATION SHEET

B. Strap type

EXAMPLE:

FIGURE 4



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VII. Common repairs needed on door glass and hardware

A. Replacing regulators

B. Adjusting regulators

(NOTE: One of the most common repairs is adjusting the regulator pivot channel on a window that will not raise or lower.)

C. Replacing glass

DOOR GLASS AND HARDWARE
UNIT II

JOB SHEET #1 — REMOVE AND REPLACE WEATHERSTRIPPING ON A DOOR

I. Equipment and materials

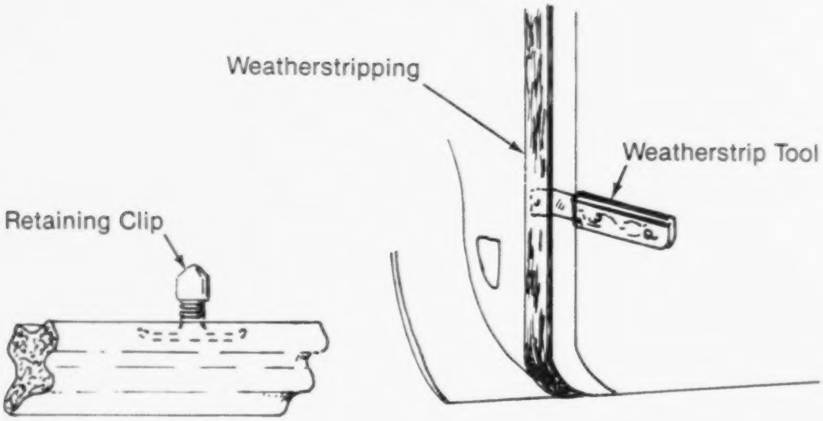
- A. Phillips screwdriver set
- B. Straight-blade screwdriver set
- C. Door-handle removal tool
- D. Trim-panel removal tool
- E. Torx wrench set
- F. Putty knife
- G. Razor-blade knife
- H. Weatherstrip-release agent
- I. Weatherstrip adhesive
- J. Trim adhesive
- K. Replacement weatherstripping
- L. Weatherstrip tool
- M. Eye protection
- N. Service manual for vehicle being worked on

II. Procedure

- A. Put on eye protection
- B. Remove door trim panel to gain access to weatherstrip fasteners

  (NOTE: Most vehicles today use both plastic fasteners and weatherstrip adhesive to retain the weatherstripping around the door.)
- C. Carefully disengage fasteners from door with weatherstrip tool (Figure 5)

FIGURE 5



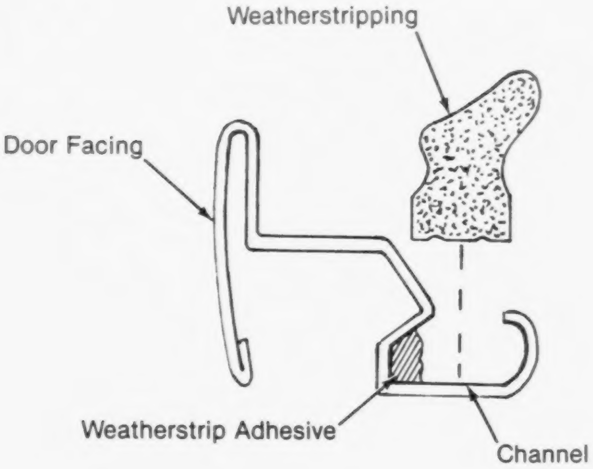
D. Inspect weatherstripping to determine areas that have been adhesive bonded

E. Apply weatherstrip-release agent to bonded areas to weaken adhesive bond

> **CAUTION**
> Follow all directions and cautions on product label.

F. Use putty knife to break adhesive bond between door and weatherstrip (Figure 6)

FIGURE 6



JOB SHEET #1

G. Install new weatherstripping

(NOTE: When previously removed weatherstripping is to be reinstalled, always inspect fasteners and replace those that are damaged. Inspect weatherstripping also. If weatherstripping is damaged at more than two consecutive fastener locations, replace with new weatherstripping.)

1. Clean all old weatherstrip adhesive from door and channel
2. Cut new weatherstripping to correct length
3. Position weatherstripping on door, and press fasteners into door piercing
4. After all fasteners have been installed, apply weatherstrip adhesive between door and loose areas of weatherstripping

   (NOTE: Although the service manual will specify weatherstrip adhesive only at specific locations, it can and should be used at any point where additional retention or sealing is required.)

H. Reinstall trim panel on door

I. Clean work area and return equipment and materials to proper storage

DOOR GLASS AND HARDWARE
UNIT II

JOB SHEET #2 — REMOVE AND REPLACE DOOR GLASS

I. Introduction

  A. Always wear gloves and safety glasses when working with glass.

  B. Be very careful when working with the window regulator. Window regulators are spring activated and can sever a finger or cause serious injury. Follow instructions and sequence of steps outlined in the service manual.

  C. Always use same thickness of glass tape as was used on the original installation.

  D. If removing channel from glass by applying heat from a welding torch, avoid direct inhalation of the fumes emitted as they may be hazardous.

II. Procedure — Follow procedure outlined in service manual for vehicle make and model you are working on.

DOOR GLASS AND HARDWARE
UNIT II

JOB SHEET #3 — REMOVE AND REPLACE A WINDOW REGULATOR

I. Introduction

A. It may be necessary to remove door glass. If so, check service manual for correct procedure. If glass removal is not necessary, block glass in the up position so that it will be out of the way.

B. Be very careful when removing the regulator. Window regulators are spring activated and can sever a finger or cause serious injury. Follow instructions and sequence of steps outlined in the service manual.

C. On some vehicle makes, the center division channel will have to be removed to allow clearance for removal of the regulator. Check the service manual.

II. Procedure — Follow procedure outlined in service manual for vehicle make and model you are working on.

DOOR GLASS AND HARDWARE
UNIT II

JOB SHEET #4 — REMOVE AND REPLACE A DOOR LATCH ASSEMBLY

I. Introduction

A. Take care not to bend control rods or break clips. Bent rods result in the door not opening properly, and clips are not available for replacement.

B. Some front door lock systems have been redesigned to prevent unlocking the door with a flat tool. The redesigned systems require close tolerances on connecting, lock, and push rods; in addition to specific rods for each different application. Evaluate the lock system carefully after a replacement part has been installed.

C. If the door striker must be replaced, do not use a replacement part of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of this part.

D. Do not attempt to make repairs to correct lock discrepancies. Make corrections only through replacement of entire lock assembly.

II. Procedure — Follow procedure outlined in service manual for vehicle make and model being worked on.

DOOR GLASS AND HARDWARE
UNIT II

TEST

NAME ________________________________ SCORE ________________

1. Match to their correct definitions terms associated with door glass and hardware. Write the correct numbers in the blanks.

_____a. Pivot channel that allows for adjustment of glass

_____b. Small wing glass that opens and shuts in an in-and-out rather than an up-and-down movement

_____c. Groove between door glass and vent glass in door with vent windows

_____d. All parts in vehicle body needed to hold or move glass

_____e. Rubber piece used to prevent glass from rolling out the top or off the bottom guides

_____f. Movable glass held in place by bolts through a channel rather than by a surrounding metal frame

_____g. Electronic device used to raise or lower windows or open or lock latches from the driver's seat

_____h. Groove used to fasten door glass to regulator

_____i. Roller or slide block that runs in channel or guide and allows glass to be raised or lowered

_____j. Glass used in vehicle windows that can be opened

_____k. Gear-operated mechanism that lowers or raises glass; may be manual or power operated

_____l. Cushioned strip used to stabilize window to prevent rattling when window is lowered

_____m. Groove in which glass slides between top and side of door

_____n. Parts that control or direct the up-and-down motion of glass; used in place of center-division channel or run channel

1. Glass hardware
2. Movable glass
3. Ventilator (vent) window
4. Regulator
5. Remote control
6. Cam
7. Stabilizer strip
8. Glass run channel
9. Center-division channel
10. Sash channel
11. Guides
12. Frameless glass
13. Equalizer arm
14. Stop

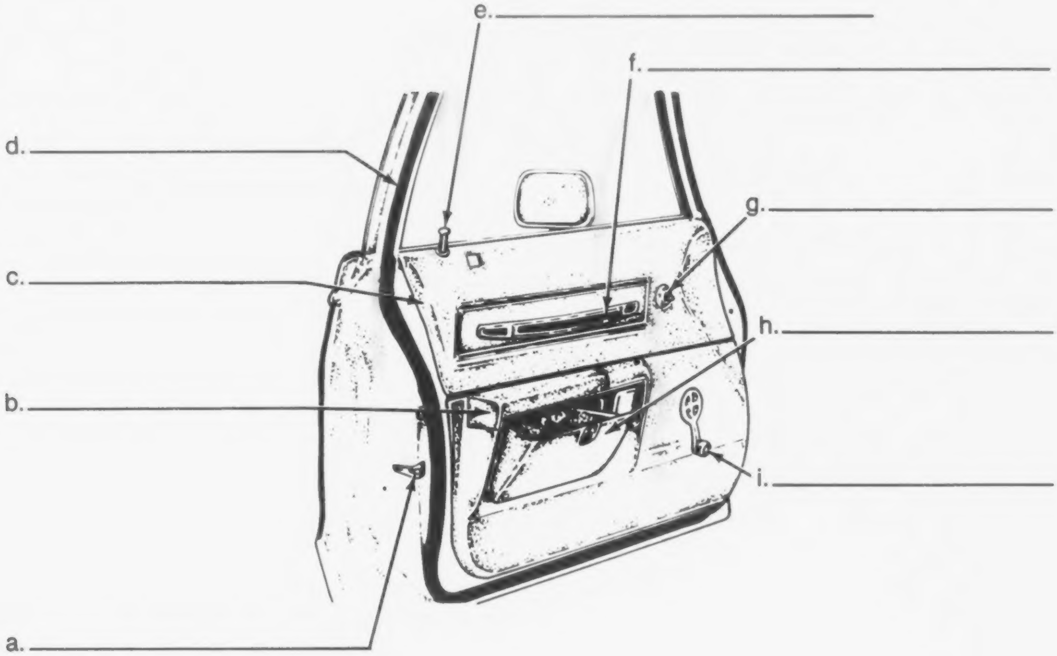
TEST

2. Distinguish between laminated safety plate glass and solid tempered plate glass. Write an "X" in the blank before the description of solid tempered plate glass.

   _____a. Treated to be less brittle than ordinary plate glass; when broken, tends to crumble into very small pieces with no sharp edges; used in side and back windows

   _____b. Layer of plastic sandwiched between two layers of glass; plastic reduces possibility of glass shattering and prevents broken pieces from flying off if glass does break; used in all windshields

3. Label the typical interior door components and hardware illustrated below.



TEST

4. List ways in which door glass is held to the door regulator.

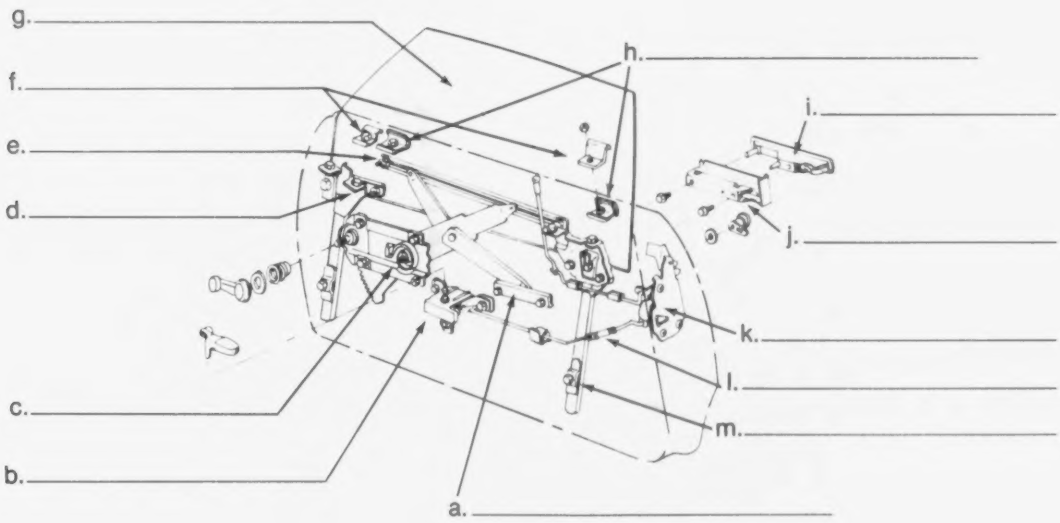
   a. ____________________

   b. ____________________

   c. ____________________

5. Identify typical door glass hardware. Write the correct names in the blanks.

   Window assembly
   Rear guide
   Door outside handle
   Window regulator
   Stabilizer strips
   Door latch
   Door outside-handle retainer
   Trim pad adjusting plates
   Lower sash channel cam
   Front guide
   Door latch remote control
   Inner panel cam
   Adjustable remote control to latch rod



TEST

6. Name types of window regulators.

   a. ______________________________

   b. ______________________________

7. Select from the following list common repairs needed on door glass and hardware. Write an "X" in the blank before each correct answer.

   ______a. Replacing run channels

   ______b. Repairing retaining clips

   ______c. Replacing regulators

   ______d. Replacing glass

   ______e. Adjusting rollers

   ______f. Adjusting regulators

(NOTE: Test item 8 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

8. Demonstrate the ability to

   a. Remove and replace weatherstripping on a door.

   b. Remove and replace door glass.

   c. Remove and replace a window regulator.

   d. Remove and replace a door latch assembly.

DOOR GLASS AND HARDWARE
UNIT II

ANSWERS TO TEST

1. a. 13
   b. 3
   c. 9
   d. 1
   e. 14
   f. 12
   g. 5
   h. 10
   i. 6
   j. 2
   k. 4
   l. 7
   m. 8
   n. 11

2. a

3. a. Door latch
   b. Armrest
   c. Trim panel
   d. Weatherstripping
   e. Door lock knob
   f. Door pull
   g. Rearview mirror control
   h. Ashtray
   i. Window regulator handle

4. a. Cam rollers and retaining clips
   b. Shoulder-type retaining bolts with plastic bushings for frameless glass
   c. Sash channel bonded to glass with urethane or structural adhesive

5. a. Inner panel cam
   b. Door-latch remote control
   c. Window regulator
   d. Front guide
   e. Lower sash channel cam
   f. Trim pad adjusting plates
   g. Window assembly
   h. Stabilizer strips
   i. Door outside handle
   j. Door outside-handle retainer
   k. Door latch
   l. Adjustable remote control to latch rod
   m. Rear guide

6. a. Arm type
   b. Strap type

7. c, d, f

8. Performance skills evaluated to the satisfaction of the instructor

STATIONARY GLASS
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to remove and replace stationary glass in a vehicle. The student will show this ability by completing the job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with stationary glass.
2. Name types of stationary glass.
3. Select from a list ways of holding stationary glass.
4. List materials used to bond stationary glass.
5. Identify specialty tools used with stationary glass.
6. Demonstrate the ability to
    a. Leak-test stationary glass.
    b. Remove and replace a gasket-type windshield or rear window.
    c. Remove and replace a gasketless windshield or rear window.

STATIONARY GLASS
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

   A. Objective sheet

   B. Suggested activities

   C. Information sheet

   D. Job sheets

      1. Job Sheet #1 — Leak-Test Stationary Glass

      2. Job Sheet #2 — Remove and Replace a Gasket-Type Windshield or Rear Window

      3. Job Sheet #3 — Remove and Replace a Gasketless Windshield or Rear Window

   E. Test

   F. Answers to test

II. Instructor's guide

   A. Review unit and plan presentation.

   B. Order or obtain materials to supplement unit.

      1. Equipment and materials for job sheet procedures

      2. Filmstrips

         a. *Windshield Replacement*

         b. *Removing Glued-In Windshields*

         c. *Installing Glued-In Windshields*

         (NOTE: The filmstrips above are available from Teaching Aids, Incorporated, Post Office Box 1798, Costa Mesa, California 92628-0798, phone [714] 548-9321.)

      3. Samples of materials used to bond or hold stationary glass

      4. Examples of each of the specialty tools listed in Section V of the information sheet

SUGGESTED ACTIVITIES

5. Competency profiles

   (NOTE: Competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss typical situations requiring the removal and replacement of stationary glass.
- Discuss unit and specific objectives, stressing that accomplishment of the specific objectives is necessary to attain the unit objective.
- Show filmstrip *Windshield Replacement* and discuss with class.

E. Discuss information and job sheets.

1. Use Information Sheet, Section I to introduce students to terms and definitions associated with stationary glass.

   SUGGESTION:

   - Show students examples of appropriate terms.

2. Use Information Sheet, Section II to discuss types of stationary glass.

3. Use Information Sheet, Sections III and IV to discuss methods of holding and bonding stationary glass.

   SUGGESTIONS:

   - Show filmstrips *Removing Glued-In Windshields* and *Installing Glued-In Windshields*.
   - Show students examples of butyl rubber, acrylic caulking, and urethane sealer.

4. Use Information Sheet, Section V to introduce students to the various specialty tools used with stationary glass.

   SUGGESTIONS:

   - Show students an example of each tool.
   - Demonstrate the proper use of each tool.

SUGGESTED ACTIVITIES

- Demonstrate Job Sheets #1 through #3, and then have students complete the job sheets under your supervision.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest if necessary.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: Gregg Division of McGraw-Hill Book Company, 1986.

B. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*, 2nd ed. Indianapolis, Indiana: Bobbs-Merrill Educational Publishing, 1983.

STATIONARY GLASS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Stationary glass — Those windows in a vehicle that cannot be opened

B. Reveal molding — Any exterior trim molding that fits around windshield, rear window, or door glass

C. Garnish molding — Any interior trim molding that fits around windshield, rear window, or door glass

D. Caulking — Watertight filler

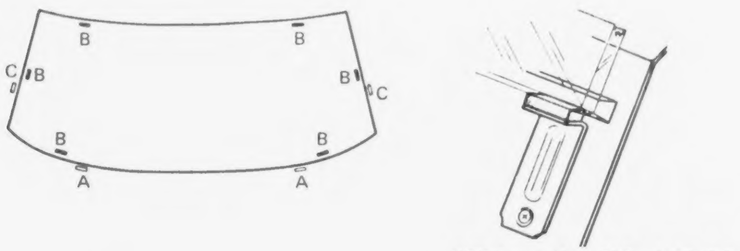
E. Adhesive — Bonding material; glue

F. Sealant — Substance used to make an area water- or airtight

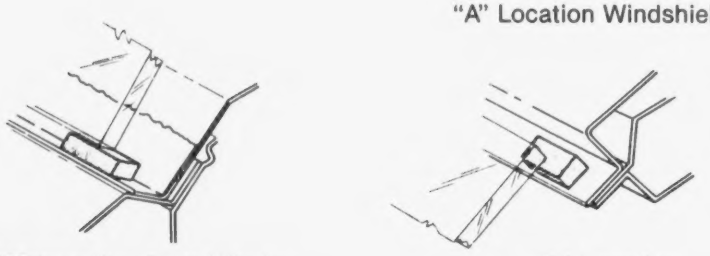
G. Check block — Flat rubber spacer that holds glass in position in opening (Figure 1)

EXAMPLE:

FIGURE 1



"A" Location Windshield



"A" Location Back Window

"B" Location

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INFORMATION SHEET

II. Types of stationary glass

  A. Windshield

  B. Rear window

  C. Opera window

  D. Quarter window

III. Ways of holding stationary glass

  A. Bonding

  B. Weatherstripping

IV. Materials used for stationary glass installation

  A. Butyl rubber tape sealer

  B. Urethane sealer

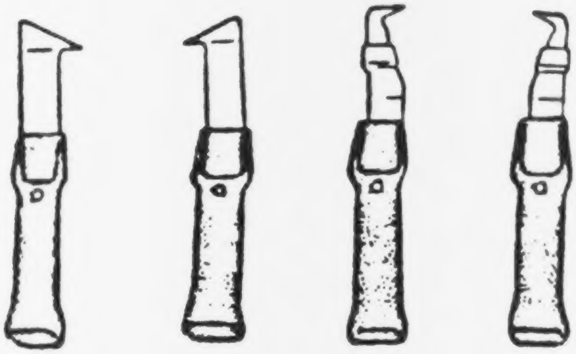
  C. Acrylic caulking

  D. Urethane adhesive

V. Specialty tools used with stationary glass (Figures 2-10)

  A. Reveal molding tool

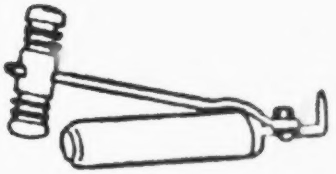
FIGURE 2: Right- and left-handed tools



INFORMATION SHEET

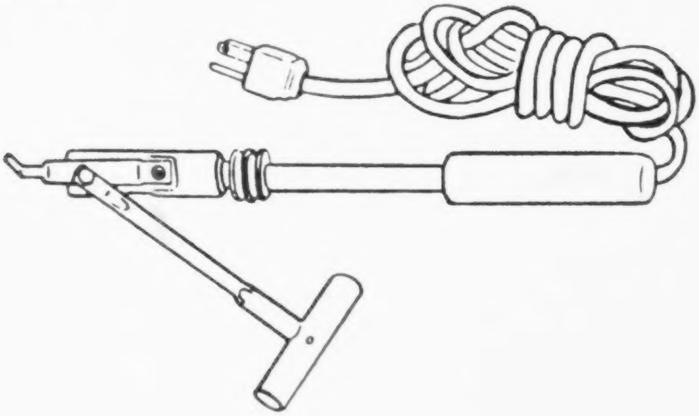
B. Windshield cold knife

FIGURE 3



C. Windshield hot knife

FIGURE 4



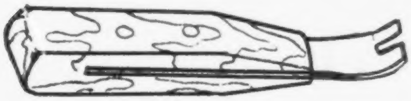
D. Cotton cord drawstring

FIGURE 5

INFORMATION SHEET

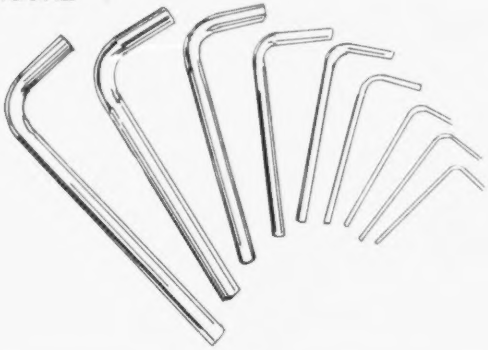
E. Plastic weatherstrip knife

FIGURE 6



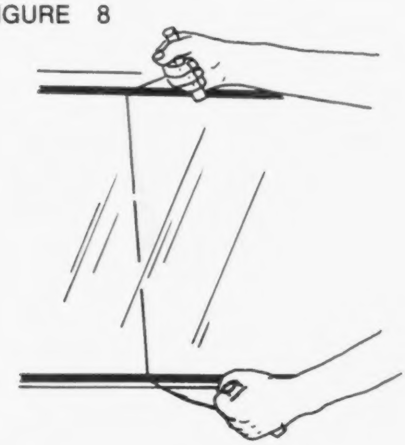
F. Allen wrench (hex key wrench)

FIGURE 7



G. Piano wire

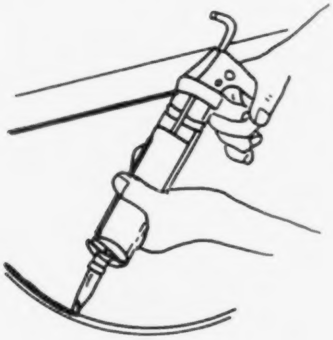
FIGURE 8



INFORMATION SHEET

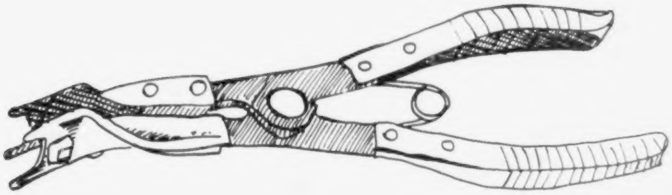
H. Caulking gun and sealant

FIGURE 9



I. Windshield wiper remover

FIGURE 10



STATIONARY GLASS
UNIT III

JOB SHEET #1 — LEAK-TEST STATIONARY GLASS

I. Equipment and materials

A. Water hose and warm water outlet

B. Urethane sealer

C. Reveal molding tool

D. Plastic paddle or disposable brush

E. Clean rags or chamois cloths

F. Window cleaner

G. Solvent

II. Procedure

(NOTE: This job requires that you locate leaks by working with an assistant who is inside the vehicle.)

A. Water-test seal by directing a soft stream of warm or hot water at seal

B. Have assistant inside vehicle pinpoint areas in which leaks are encountered

C. Remove window reveal moldings

D. Dry areas in which leaks are encountered, and paddle or brush on extra urethane sealer at leak point

E. Check again with soft stream of warm or hot water

CAUTION

Do not direct hard stream of water at fresh sealer material as this will damage the seal.

F. When no more leaks are found, clean excess sealer from glass with clean rag and solvent

G. Reinstall window reveal moldings

H. Clean remaining portion of glass with window cleaner and clean, soft rag or chamois cloth

I. Allow sealant on window to cure for at least 6 hours

J. Clean work area and return equipment and materials to proper storage

STATIONARY GLASS
UNIT III

JOB SHEET #2 — REMOVE AND REINSTALL A GASKET-TYPE WINDSHIELD OR REAR WINDOW

I. Equipment and materials

- A. Appropriate wrenches and socket sets
- B. Phillips and straight-blade screwdriver sets
- C. Reveal molding tool
- D. Replacement glass
- E. Hex wrench set
- F. Weatherstrip adhesive
- G. Trim adhesive
- H. Oil, grease, or soap for lubricant
- I. Plastic weatherstrip knife
- J. Sealing gun and appropriate sealer
- K. Cleaning solvent and clean cloths
- L. 1/4-inch cotton cord drawstring approximately 10 feet long
- M. Eye protection, leather gloves, and high-topped boots
- N. Masking tape
- O. Hood, fender, and upholstery covers
- P. Service manual for vehicle being worked on

II. Procedure

(NOTE: Windshield or rear window removal and installation can be done by one person, but an assistant is recommended. Do not attempt to perform this job sheet unless your instructor is present.)

- A. Cover hood and dash or deck and panel shelf with protective cover
- B. Put on high-topped boots, eye protection, and leather gloves

JOB SHEET #2

C. If you are going to remove windshield and it is equipped with a built-in antenna, disconnect antenna by prying snap-on lead from glass with plastic knife; tape lead to glass so that it will not get damaged

D. If you are going to remove rear window and it is equipped with an electric defroster, check service manual for proper procedures and then disconnect defroster lead; tape lead to window so that it will not get damaged

CAUTION

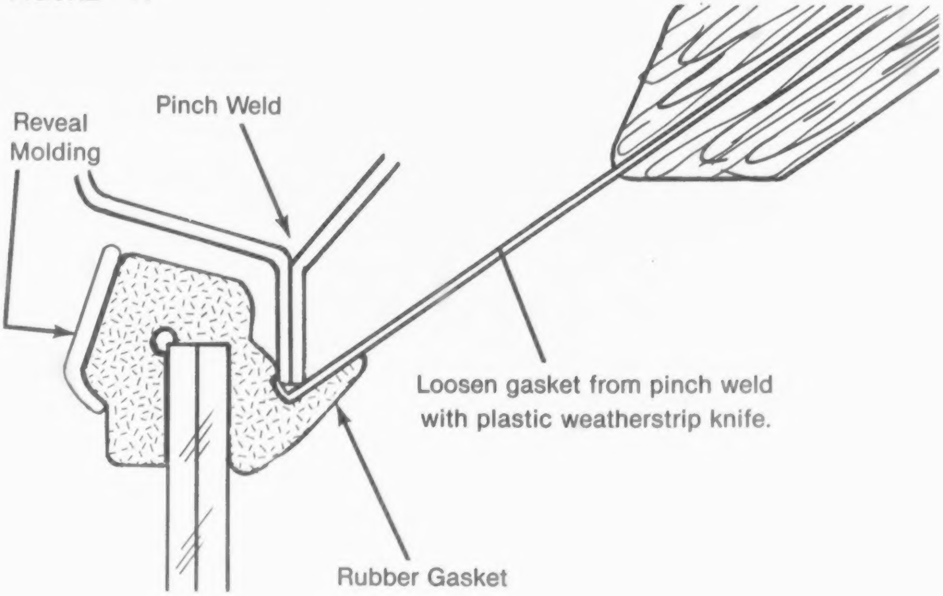
The engine must be off when you work on a rear window that has a heating element. The voltage is high enough to give you an extremely severe shock.

E. Remove all interior trim that will interfere with procedure—garnish moldings, rearview mirror, sun visors, etc.

F. Remove all exterior moldings and trim that will interfere with procedure—reveal moldings, cowl vent cover, windshield wipers, etc.

G. Use plastic weatherstrip knife to loosen gasket from pinch weld (Figure 11)

FIGURE 11


Pinch Weld
Reveal Molding
Loosen gasket from pinch weld with plastic weatherstrip knife.
Rubber Gasket

H. Cover upholstery and then remove glass, using your hands or feet to push it out slowly

CAUTION

Take care not to apply sudden force or pressure that could break or shatter the glass. Always wear leather gloves and high-topped boots for this procedure.

JOB SHEET #2

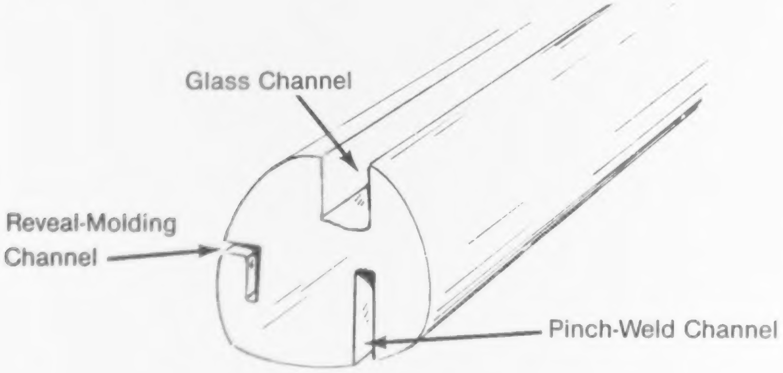
I. Peel gasket from edge of damaged glass, and discard glass

J. Clean gasket (Figure 12)

(NOTE: The gasket must be thoroughly and carefully cleaned. Any traces of glass or dirt left in a channel could cause the new window to break.)

1. Clean glass channel with clean cloth and cleaning solvent
2. Clean reveal-molding channel with clean cloth and cleaning solvent
3. Clean pinch-weld channel with plastic knife, cleaning solvent, and clean cloth

FIGURE 12



K. Install gasket on replacement glass, placing weatherstrip channel on edge of glass and pressing until fully seated

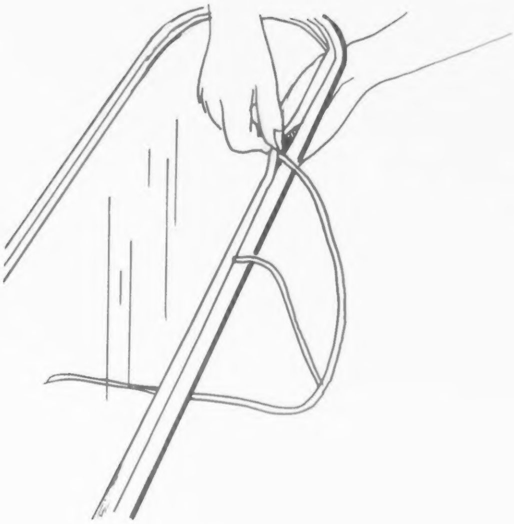
L. Use plastic knife to pry lip of molding channel outward, and then slide molding into channel

M. Use a rag or your hand to lubricate outside of gasket

N. If using the pull-string method, install string in pinch-weld gasket channel (See Figure 13)

JOB SHEET #2

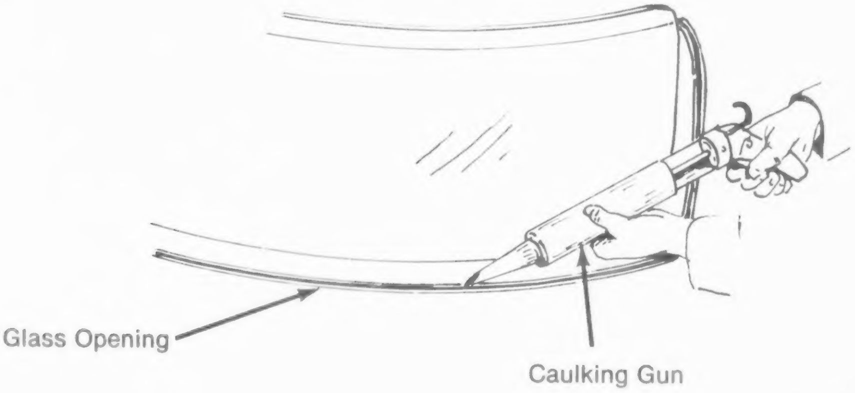
FIGURE 13



O. Place glass—with gasket installed—in glass opening of vehicle, making sure that glass is centered in opening

P. Seal around body opening before seating glass (Figure 14)

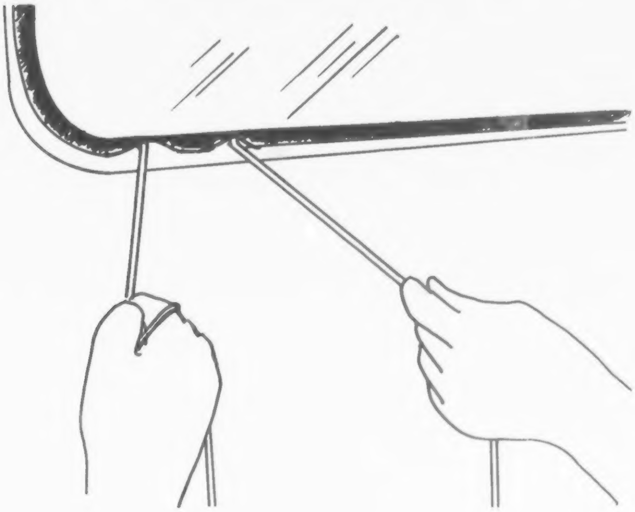
FIGURE 14



JOB SHEET #2

Q. Seat glass by pulling pinch-weld channel lip over body pinch weld, either by pulling string around opening or by prying with weatherstrip knife (Figure 15)

FIGURE 15: Pulling string to force channel over pinch-weld flange



R. Slap glass with palm of hand to ensure proper seat in opening

> **CAUTION**
>
> To prevent breaking the glass, make sure that you have removed all rings before slapping glass.

S. Reconnect antenna or defroster lead if applicable

T. Reinstall all exterior moldings and trim removed earlier, making sure not to overtighten bolts or screws

(NOTE: Overtightening bolts or screws may put enough pressure on glass to break it.)

U. Reinstall all interior moldings and trim removed earlier

V. Seal glass between glass and channel

W. Use approved cleaner (see service manual) to clean all excess sealer from glass, vehicle body, moldings, and trim

X. Check seal for leaks as described in Job Sheet #1

Y. Check to see that windshield wipers operate properly

Z. Clean glass with water and clean cloths or chamois

AA. Clean work area and return equipment and materials to proper storage

STATIONARY GLASS
UNIT III

JOB SHEET #3 — REMOVE AND REINSTALL A GASKETLESS WINDSHIELD OR REAR WINDOW

I. Equipment and materials

A. Weatherstrip adhesive

B. Trim adhesive

C. Plastic weatherstrip knife

D. Piano wire

E. Pieces of dowl for handles on piano wire

F. Scratch awl

G. Windshield cold knife

H. Windshield hot knife

I. Putty knife

J. Cleaning solvent and clean cloths

K. Replacement glass

L. Urethane adhesive

M. Masking tape

N. Eye protection, leather gloves, and high-topped boots

O. Hood, fender, and upholstery covers

P. Service manual for vehicle being worked on

II. Procedure

(NOTE: Windshield or rear window removal and installation can be done by one person, but an assistant is recommended. Do not attempt to perform this job sheet unless your instructor is present.)

A. Cover hood and dash or deck and panel shelf with protective cover

B. Put on high-topped boots, eye protection, and leather gloves

JOB SHEET #3

C. If you are going to remove windshield, and it is equipped with built-in antenna, disconnect antenna by prying snap-on lead from glass with plastic knife; tape lead to glass so that it will not get damaged

D. If you are going to remove rear window, and it is equipped with an electric defroster, check service manual for proper procedure and then disconnect defroster lead; tape lead to window so that it will not get damaged

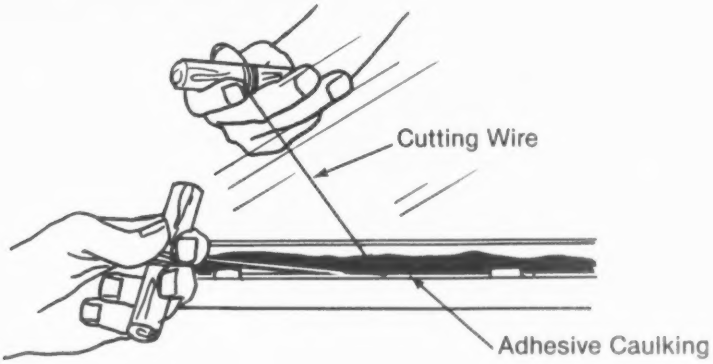
> **CAUTION**
>
> The engine must be off when you work on a rear window that has a heating element. The voltage is high enough to give you an extremely severe shock.

E. Remove all interior trim that will interfere with procedure—garnish moldings, rearview mirror, sun visor, etc.

F. Remove all exterior moldings and trim that will interfere with procedure—reveal moldings, cowl vent cover, windshield wipers, etc.

G. Cut glass from body of vehicle, using most appropriate of the following methods (Figures 16-18)

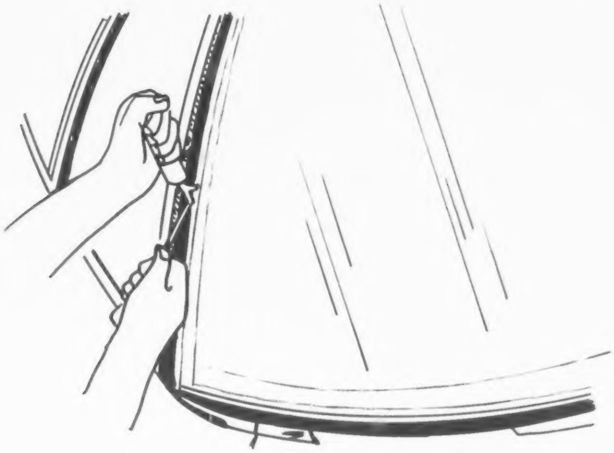
FIGURE 16: Piano-wire method



1. Use scratch awl to punch hole in caulking
2. Insert piano wire through hole
3. Attach dowel handles to ends of piano wire
4. While assistant holds one end, saw wire back and forth while pulling wire along length of glass to separate caulking from pinch weld
5. Run piano wire completely around glass until glass has separated from pinch weld

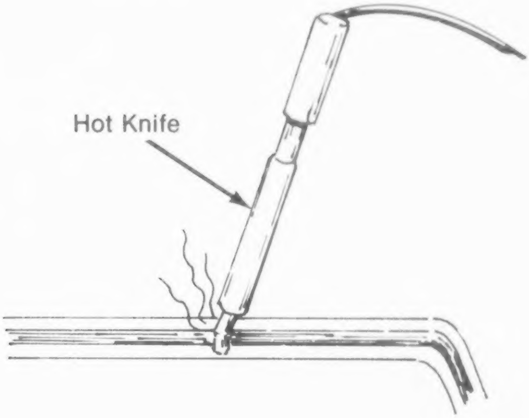
JOB SHEET #3

FIGURE 17: Windshield cold-knife method



1. Insert cutting edge of knife into caulking between glass and pinch weld
2. Holding knife firmly in one hand, pull T-handle on knife with other hand, pulling knife slowly around glass to cut caulking and separate glass from pinch weld
3. Remove knife from caulking

FIGURE 18: Windshield hot-knife method



JOB SHEET #3

1. Connect hot knife to power source and allow to heat up on nonflammable surface for several minutes

2. Insert cutting edge of knife into caulking between glass and pinch weld

CAUTION

When using the hot knife, do not inhale the fumes of the burning material. Always ensure adequate ventilation in work area.

3. Pull knife steadily around glass until glass has separated from pinch weld

CAUTION

Do not allow knife to remain in one place for very long as the heat will melt the caulking back together.

4. Pull knife from channel, disconnect from power source, and lay on nonflammable surface to cool

H. Cover upholstery and then remove damaged glass, using your hands or feet to push it out slowly; discard

CAUTION

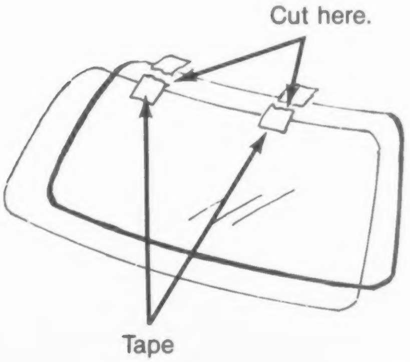
Take care not to apply sudden force or pressure that could break or shatter the glass. Always wear leather gloves and high-topped boots for this procedure.

I. Use putty knife to scrape away any caulking remaining in glass opening

J. Center replacement glass in opening

K. Position two pieces of masking tape on glass, overlapping roof as shown in Figure 19; cut tape between glass and roof

FIGURE 19



JOB SHEET #3

L. Carefully clean pinch weld and opening with solvent and clean rag to remove any remaining traces of caulking

M. Prep edge of replacement glass with cleaner

N. Replace seal by carefully positioning urethane tape along edges of replacement glass

O. Remove paper backing material from urethane tape

P. Have assistant help you lift glass and carefully position it in opening, aligning masking tape on roof with that on glass, and resting glass on lower checking blocks

Q. Slap glass with palm of hand to ensure proper seat in opening

> **CAUTION**
>
> To prevent breaking the glass, make sure that you have removed all rings before slapping the glass.

R. Check seal for leaks as described in Job Sheet #1

S. Reconnect antenna and defroster lead if applicable

T. Reinstall all exterior moldings and trim removed earlier, making sure not to overtighten bolts or screws

(NOTE: Overtightening bolts or screws may put enough pressure on glass to break it.)

U. Reinstall all interior moldings and trim removed earlier

V. Check to see that windshield wipers operate properly

W. Clean glass with water and clean cloths or chamois

X. Clean work area and return equipment and materials to proper storage

STATIONARY GLASS
UNIT III

TEST

NAME ______________________________ SCORE ______________

1. Match to their correct definitions terms associated with stationary glass. Write the correct numbers in the blanks.

_____a. Any interior trim molding that fits around windshield, rear window, or door glass

_____b. Those windows in a vehicle that cannot be opened

_____c. Bonding material; glue

_____d. Flat rubber spacer that holds glass in position in opening

_____e. Any exterior trim molding that fits around windshield, rear window, or door glass

_____f. Watertight filler

_____g. Substance used to make an area water- or airtight

1. Stationary glass
2. Garnish molding
3. Check block
4. Reveal molding
5. Sealant
6. Adhesive
7. Caulking

2. Name types of stationary glass.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

3. Select from the following list ways of holding stationary glass. Write an "X" in the blank before each correct answer.

_____a. C-clamps

_____b. Bonding

_____c. Vice-grip pliers

_____d. Weatherstripping

_____e. Masking tape

TEST

4. List materials used to bond stationary glass.

a. ____________________

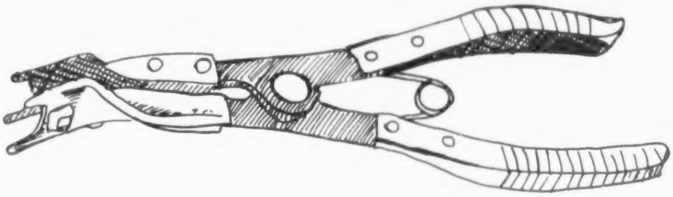
b. ____________________

c. ____________________

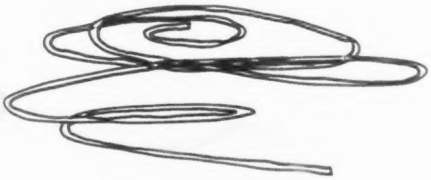
d. ____________________

5. Identify the following specialty tools used with stationary glass. Write the correct names in the blanks.

Reveal molding tool
Windshield cold knife
Windshield hot knife
Piano wire
Caulking gun and sealant
Cotton cord drawstring
Plastic weatherstrip knife
Allen wrench (hex key wrench)
Windshield wiper remover

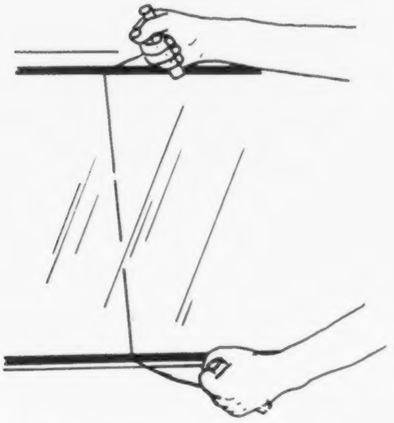


a. ____________________

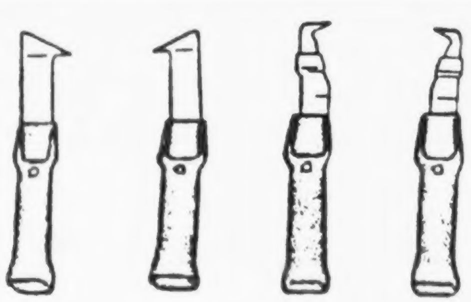


b. ____________________

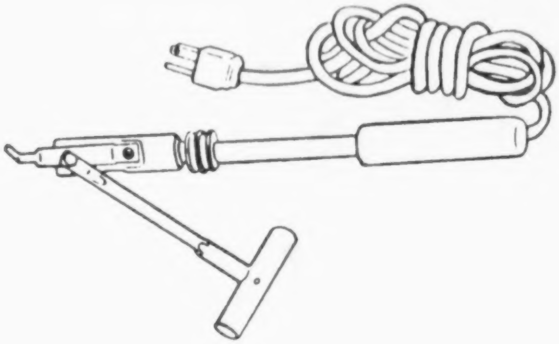
TEST



c. ____

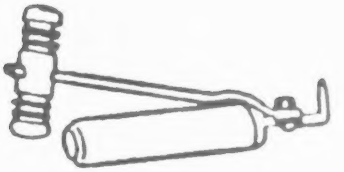


d. ____

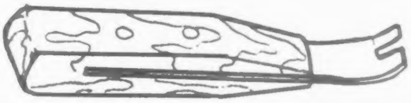


e. ____

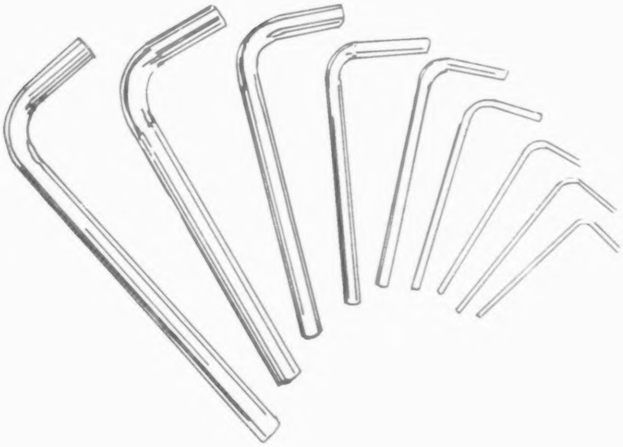
TEST



f. ____

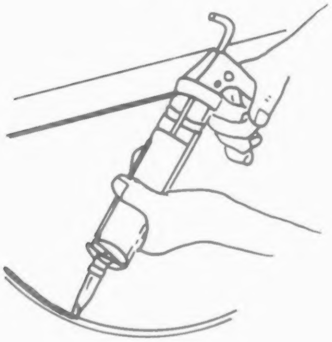


g. ____



h. ____

TEST



i. ____

(NOTE: Test item 6 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

6. Demonstrate the ability to

   a. Leak-test stationary glass.

   b. Remove and replace a gasket-type windshield or rear window.

   c. Remove and replace a gasketless windshield or rear window.

STATIONARY GLASS
UNIT III

ANSWERS TO TEST

1. a. 2
   b. 1
   c. 6
   d. 3
   e. 4
   f. 7
   g. 5

2. a. Windshield
   b. Rear window
   c. Opera window
   d. Quarter window

3. b, e

4. a. Butyl rubber tape sealer
   b. Urethane sealer
   c. Acrylic caulking
   d. Urethane adhesive

5. a. Windshield wiper remover
   b. Cotton cord drawstring
   c. Piano wire
   d. Reveal molding tool
   e. Windshield hot knife
   f. Windshield cold knife
   g. Plastic weatherstrip knife
   h. Caulking gun and sealant
   i. Allen wrench (hex key wrench)

6. Performance skills evaluated to the satisfaction of the instructor